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JOURNAL OF THE AERONAUTICAL SCIENCES

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On the Causes and the Forecasting of the California Fog

SVERRE PETTERSSEN, *Vervarslingi paa Vestlandet, Bergen, Norway*

(Received May 7, 1936)

SUMMARY

INVESTIGATIONS of the California fog by means of aerological ascents from San Diego California showed that the fog is not caused by the direct cooling of the cold upwelling water along the coast. The air which produces fog is unstable and the fog or stratus forms because of convection under the temperature inversion separating the Pacific air from the dry air aloft. Outgoing radiation from the top of the moist layer is effective in maintaining the temperature inversion and the instability of the air. Remarkable correlations are found between the time when the fog breaks and the distance between the condensation level and the base of the inversion. This relation, and the relation between the diurnal amplitude of temperature and the height of the base of the inversion give valuable rules for the forecasting of fog for Southern California. Comments are made on the periodic and aperiodic variations of the condensation level and the base of the inversion as well as on the formation of "day fog."

INTRODUCTION

Viewed from a metrological standpoint, the weather phenomena, such as clouds and hydrometeors, may be divided in three rather distinctly different classes, namely:

(a) Weather phenomena in an air mass which is colder than the surface over which it travels. Such an air mass is called a *Cold Mass.*

(b) Weather phenomena in an air mass which is warmer than the surface over which it travels. Such an air mass is called a *Warm Mass.*

(c) Weather phenomena which occur along the border between two adjacent air masses of different temperature. These weather phenomena are called Frontal phenomena.

Before beginning to discuss the California fog,[1] it will be useful to describe briefly the weather phenomena characteristic of Warm and Cold Air Masses.

COLD AIR MASS PHENOMENA

An air mass which is colder than the surface over which it travels will be heated from below. The absorption of heat from below results in thermal *instability,* which favors turbulence and convective currents. In this way heat and moisture are transported upwards.

The cloud forms characteristic of a cold air mass are cumuliform clouds; that is to say, all variations from flat *cumulus humilis* to towering *cumulonimbus.*

The precipitation forms of a cold mass are always of a showery or squally character.

WARM AIR MASS PHENOMENA

An air mass which is warmer than the surface over which it travels will be cooled from below. The cooling from below creates thermal *stability.* Stability hinders convection and turbulence, and there is only very slight transport of heat and moisture upwards.

The cloud forms characteristic of a warm mass are stratiform clouds of low altitude, such as mist[2], fog

[1] In accordance with common usage the term *California fog* is used here even though the term *California stratus* would be more adequate.

[2] *Mist* is here used in the international meaning, i.e. thin fog whose visibility is greater than 1 kilometer.

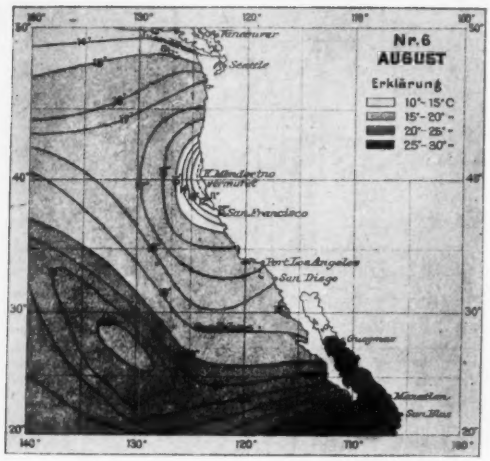


FIG. 1.

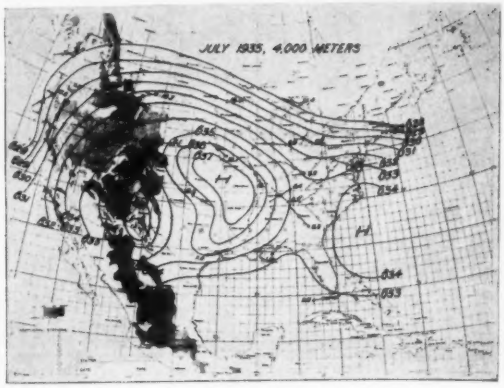


FIG. 2.

or stratus. The forms of precipitation which occur in a warm mass are drizzle and rain consisting of very small droplets.

We thus see that *fog* and *stratus* usually are warm air mass phenomena, and this might be expected to be true also for the California fog.

STABILITY OF THE FOG AIR

Aerological ascents in recent years show that the air which normally produces fog on the California coast in Summer and Autumn is rather *unstable*. Slightly superadiabatic lapse rates occur quite frequently in the day time, and even during the night there is no marked tendency to produce stability. This is particularly true of the air in the fog itself. Thus at San Diego it happens frequently that the temperature lapse rate in fog is considerably larger than the moist adiabatic rate, which indicates that the air which produces the fog is unstable. In this way the California fog—or stratus—differs from the ordinary kind of fog.

SEA-SURFACE TEMPERATURE

Since the California fog behaves differently from the usual kind of fog, it seems natural to look around for some local conditions which might influence the phenomena. It is then natural to study the distribution of the sea-surface temperature and the trajectories of the air masses. Fig. 1 shows the sea surface isotherms[3] in August. It is seen that there is a very distinct minimum of sea-surface temperature north of San Francisco with increasing temperature northward and southward.

The main air current off the coast in August is from the N.W. Air that moves in over colder water will be cooled from below and might well produce fog, but in that case the air ought to be stable and not unstable as it usually is. This cooling effect of the sea surface cannot be the direct cause of the fog, because it is frequently observed in San Diego that fog forms with the air current from the N.W., and the air would then be heated, and not cooled from below.

There can, however, be little doubt that the presence of cold water along the coast greatly influences the air masses in California, and indirectly it may have a large influence on the formation of fog; but it is not satisfactory to say that there is fog in California because of the cold water along the coast. The cold water will keep the air temperature generally low and the relative humidity generally high, and this, of course, favors the formation of the fog.

THE HIGH LEVEL ANTICYCLONE

Having mentioned briefly the properties of the surface over which the air travels, we turn to the upper strata of the atmosphere in order to see what influences might come from above. Fig. 2 shows a typical distribution of atmospheric pressure in the level of 4 km. over the United States in summer.[4] At low levels, particularly in the southwest portion, there is a semi-permanent area of low pressure, but with increasing altitude the "low" vanishes and changes into a high level anticyclone.[5] From such a "high" there is lateral outflow and, as a consequence, descending motion. The descending motion results in adiabatic heating of the air and correspondingly decreasing relative humidity.

[3] H. Thorade, *Uber die kalifornische Meeresströmung*, Ann. der. Hydr. und mar. Met. 1909.

[4] See also: Thomas R. Reed, *The North American High Level Anticyclone*, Monthly Weather Review, Vol. 61 p. 321, 1933.

[5] This high level anticyclone should be regarded as an independant cell between the Atlantic and the Pacific cells of the general circulation. This new continental cell at high levels differs from the ordinary subtropical cells (See V. Bjerknes, J. Bjerknes, H. Solberg, und T. Bergeron, *Physikalische Hydrodynamik*, p. 679, Julius Springer, Berlin 1933.) in that respect that it spreads above both the neighboring cells. This continental cell is undoubtedly responsible for the production of the warm and dry air aloft, which meteorologists usually call T^c.

The Structure of the Air

Fig. 3 shows a typical distribution of temperature and humidity as functions of altitude, with cold and moist air under a marked temperature inversion above which there is warm and dry air up to great altitudes.

There can be little doubt that the cold and moist air below the inversion is of Pacific origin. It is moist because it has been in contact with the sea, and it is cold because of the cold upwelling water along the coast.

Opinions vary with respect to the origin of the dry air above the inversion. Some meteorologists contend that this air is dry and warm because of the influence of the deserts. The author thinks it is more logical to say that there are deserts because the air is dry and warm. It is the sub-tropical anticyclones with their prevalent subsiding air movement which are responsible for the deserts, and not visa versa.

That the dryness of the air aloft is not caused by the influence of the deserts is made evident by the fact that the air in these regions is excessively dry up to very great altitudes, and the relative humidity decreases upwards. Relative humidities at the level of 5 to 6 km. are frequently below 10 per cent, and sometimes even below 1 per cent. If this air came from the desert, the relative humidity would increase with altitude, and the air would be saturated or close to its saturation point at 6 km. altitude.

Maintenance of the Inversion

The Pacific air at low levels is separated from the warm and dry air above by means of the temperature inversion consisting of a layer of extremely stable air. This inversion acts as a lid through which no transport or mixing of air takes place. The only way in which the two air masses can exchange properties is via radiation, and since the upper air is considerably warmer than the air below, it might, *prima facie*, seem plausible that radiation would be very effective in destroying the inversion, and, in that case, it would be difficult to explain why the inversion is an almost permanent phenomenon during the foggy season. A closer examination will, however, show that owing to the great difference in the moisture content of the air masses involved the radiative flux of heat may be directed from the colder and moister mass towards the warmer and dryer.

The radiation (R) follows the well known Stefan's law

$$R = cT^4 \qquad (1)$$

where c is a constant characteristic of a black body, and T is absolute temperature.

The radiation of moist air R' depends largely on the content of moisture, and Brunt[6] has recently shown that the radiation of moist air can be expressed with very great accuracy by the following equation

$$R' = cT^4\,(0.526 + 0.065\sqrt{e}) \qquad (2)$$

where e denotes the partial pressure of the water vapor. It is then easily seen that the net radiation from the warm and dry air towards the cold and moist air underneath is greatly reduced because of the great difference in water vapor, and for extreme differences in water content, radiation from the cold towards the warm air may occur.[7]

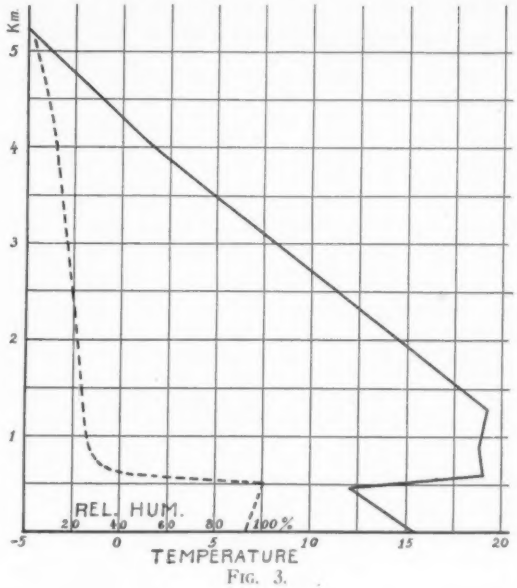


Fig. 3.

This applies to non-saturated air. When the saturation point is reached, and stratus forms under the inversion, the outgoing radiation at night time from the upper surface of the cloud layer will be that of a black body, Eq. (1), whereas the outgoing radiation from the warmer and dryer air immediately above the cloud layer, will be that of a "gray" body as given by Eq. (2), which rarely amounts to more than 66 per cent of the black body radiation. Thus, on foggy nights, the air under the inversion radiates more heat outward than the air above. In this way the inversion is maintained and even increased during the night, and, since the air under the inversion is cooled from above, it follows that the air mass that produces fog is kept in an unstable state. In the daytime, when the "fog burns off," the surface of the earth absorbs sufficient radiation to heat the air from below so that the air usually is kept in an unstable state also during the day. The unstable state of this air is directly

[6] David Brunt, *Physical and Dynamical Meteorology*, p. 123, Cambridge University Press, Cambridge, 1934.

[7] Edward H. Bowie, *The Summer Nighttime Clouds of the Santa Clara Valley, California*, Monthly Weather Review, Vol. 61, pp. 40–41, 1933.

observable from the internal motion of the clouds, and also experienced as "bumpiness" by pilots.[8]

The Formation of the Fog

It is now easy to form a clearer idea of the mechanism of the fog formation. It has already been shown that the fog is not directly formed by cooling from below, because then it ought to have a stable stratification. The pronounced instability and the radiative conditions seem to indicate that the fog is formed by some convective process, and it is the aim of this paragraph to prove this assumption by means of airplane ascents from the Naval Air Station at San Diego, California, which the U. S. Navy Department Bureau of Aeronautics kindly has provided for this study.

(a) If the fog is of convective nature, it follows that the base of the layer should coincide with the condensation level of the surface particles. Actual observations show that the base of the stratus is *slightly* higher than the condensation level. This difference is probably due to mixing of the ascending currents with non-saturated air above, but, owing to inevitable inaccuracy in ceiling observations, the magnitude of this slight difference is uncertain.

(b) It is also to be expected that fog could only be present when the condensation level of the surface air is lower than the base of the inversion, because otherwise condensation could not take place through convection. Table I shows the frequencies of unbroken fog, scattered fog, and clear sky (except for high clouds) at the Naval Air Station at San Diego, California, at the time of the morning ascents. In the left hand column of this table, $(BI—CL)$, are given the distances from the condensation level, CL, of the surface air to the base of the inversion, BI. The negative distances in the lower half of the column indicate that the base of the inversion was below the condensation level of the surface air.

This table shows: (1) that all cases of unbroken fog occurred when the condensation level was below the base of the inversion, (2) scattered fog occurred when the condensation level is close to the base of the inversion, and (3) all cases without fog occurred when the condensation level was higher than the base of the inversion.

(c) Taking it for granted that the fog is formed through convection, it follows that the fog ought to burn off early when the distance $(BI—CL)$ is small (thin fog layer) and late when this distance is larger (thick fog layer). In order to test this the correlation coefficient between $(BI—CL)$ and the hour when the fog broke was worked out. The correlation coefficient is 0.84 ± 0.04, which shows that there is an almost linear relation between the two elements.

Table I

San Diego, Calif. Morning Ascents.

BI—CL	Unbroken Fog	Scattered Fog	Clear
400m....			
300– 400.....	3		
200– 300.....	9	1	
100– 200.....	7		
0– 100.....	8	5	
−100– 0.....	.....	.....	1
−200– −100.....	.....	.....	5
−300– −200.....	.....	.....	4
−400– −300.....	.....	.....	2
−400.....	.....	.....	12

The author believes that the above evidence strongly corroborates the assumption that the California fog is formed by convection and turbulent mixing in the air under the inversion. If the fog formed because of cooling from below, the air would be stable and not unstable as it actually is; and if the fog appeared because of horizontal transport of air from the ocean, there could hardly be such a close correlation between the behavior of the fog and the properties of the surface air.

The Influence of the Height of the Inversion

It has been shown in the previous paragraph that the time of "burning off" is closely related to the distance from the condensation level to the base of the inversion, and even though the coefficient is large, it is not perfect. It is, however certain that the distance $(BI—CL)$ is not the only deciding factor for determining the hour when the fog will break. The height of the base of the inversion above the ground should also be taken into consideration.

Since the air under the inversion is unstable, the heat gained from the surface by the air after sunrise will be distributed over the whole air column under the inversion. When the inversion is high, the diurnal amplitude of temperature at any level will be small, and its effect on dissolving the fog will be small. When the base of the inversion is low the diurnal amplitude of temperature will be large, and its effect on the fog will be large. Table II shows the mean values of the diurnal amplitude A as a function of the height of the base of the inversion BI above the Naval Air Station, San Diego, California.

It is seen from this table that the diurnal amplitude of temperature is inversely proportional to the height of the air column under the inversion.

From the above it seems safe to conclude that the relation between the time of breaking and $(BI—CL)$, as given in the paragraph on *The Formation of the*

[8] Interesting observations have been described by J. B. Anderson, *Observations from Airplanes of Clouds and Fog Conditions along the Southern California Coast*, Monthly Weather Review, Vol. 59, pp. 264–270, 1931.

TABLE II

BI (meters)	A (°F)
0– 50	23
0–100	17
100–200	14
200–300	10
300–400	9
400–500	7
500–600	7
600–700	7
700–800	8
800–900	1

Fog, is the normal relation for average height of the base of the inversion. But when *BI* itself is large the fog will break later than normal, and, conversely, when *BI* is small, the fog will break earlier than normal. Observations are, however, too scanty as yet to give reliable correlation coefficients for various values of the height of the base of the inversion.

DIURNAL VARIATION OF THE CONDENSATION LEVEL AND THE BASE OF THE INVERSION

The average altitude of the condensation level of the surface air in San Diego at 6 a.m. was 500 m. At 3 p.m. it was 963 m. The condensation level is, therefore, subject to a considerable diurnal variation in altitude.

The corresponding diurnal variation in the height of the base of the inversion (40 meters)[9] is negligible against the diurnal amplitude of the condensation level which moves in a regular rhythm in time with the diurnal variation in temperature. The fog burns off in the morning when the condensation level coincides with the base of the inversion, and the sky remains clear till the decending condensation level coincides with the base of the inversion. It is, therefore, easily understood that forecasting of fog in South California is only possible on the basis of aerological ascents. Without soundings, forecasting of this kind of fog will have to be based on rules of thumb and guessing. But with a sufficient number of ascents the author believes that the forecasting of the fog would be substantially improved.

THE MOVEMENT OF THE INVERSION

The diurnal variation in the height of the base of the inversion is negligible, but the base of the inversion moves aperiodically, and its movement depends on the changes in the general weather situation. For forecasting of the fog it is of crucial significance to be able to forecast whether the inversion is going to rise or lower.

TABLE III

Quadrant	Height
N	210 m.
E	200 m.
S	640 m.
W	450 m.

The movement of the inversion has been correlated to many meteorological elements, and the deciding factor seems to be the direction of the air current under the inversion. Table III shows the average heights of the base of the inversion for wind directions from the four significant quadrants:

From this table, and also from synoptic studies, it follows that when the wind changes to a northerly or easterly direction the inversion will lower. Simultaneously, advection of drier air will cause the condensation level to rise, and the chances for fog decrease. If the wind is expected to change to a westerly or southerly direction the inversion will rise and, owing to the advection of moister air, the condensation level will lower, and the chances for fog will increase.

DAY FOG

After clear nights it was observed a few times that fog formed soon after sunrise, and, at first sight, this phenomenon seemed to be at variance with the above explanation of the formation of the fog. A closer study of the ascent curves showed that in these cases there were two inversions, a slight secondary inversion below the condensation level and a primary one above. The secondary inversion would then prevent convection up to the condensation level, and hence a clear night. Soon after sunrise the heating of the ground destroyed the lower secondary inversion with the result that convection could reach up to and above the condensation level, causing the fog to form. Usually the fog dissolved later in the day.

The above results refer to the conditions in San Diego where the meteorological conditions are extremely simple and regular, and this circumstance probably accounts for the high correlations obtained. There can, however, be little doubt that similar investigations in other localities would render valuable results even though the correlations might be less pronounced.

[9] See also: Dean Blake, *Further Conclusions from Additional Observations in the Free Air over San Diego, California*, Monthly Weather Review, Vol 62, pp. 195–199, 1934.

Photoelastic Stress Analysis in Monocoque Construction*

I. B. YASSIN, *New York City*

(Received December 19, 1935)

THE monocoque fuselage represents a very desirable type of construction for the airplane because of such advantages as simplicity, freedom from unfavorably situated structural members, roominess, torsional rigidity, and in metal skin jobs a better strength reaction after failure than the welded tubular structure. American manufacturers have been quite successful in utilizing either the pure monocoque type, consisting of skin and bulkheads, or a reinforced modification of it; and generally speaking, these types are prevalent.

The aircraft designer uses such construction warily because of unfamiliarity with its real strength as compared with the relative certainty of strength of a conventionally stress-analyzed tubular fuselage. Those manufacturers who use it have developed, through research and tests, fairly satisfactory formulae for the strength of their designs, but realize that they often add unnecessary weight because of the unknown stress distribution in the skin.

However, strength analyses of indeterminate structures of the monocoque type can be made easier by the photoelastic method.

If different materials that are isotropic and homogeneous obey the same laws of stress and strain, such as Hooke's Law, Young's Modulus, and Poisson's Ratio, the stress effects of one can easily be proportioned into effects in the other and quite accurate values computed. Thus the substitution of celluloid for aluminum and its alloys is feasible, because they conform sufficiently to these laws. The photoelastic theory and technique which employs these hypotheses is fully covered in easily obtained references.

To illustrate the application of this method for monocoque analysis, a model side-panel as shown in Fig. 1 was made of unstressed celluloid, ¼ in. thick, the design being a matter of judgment. The shape and general proportioning of the windows and the door were made comparable to known ships. The relative positions of the windows and door to the spar and other loads are conventional, yet are in the most critically stressed portion of the panel. Concentrated loads were used, those representing the ship's weight being applied at proper section points; and as a cantilever monoplane semblance, the lift supports are front and rear spar loads at the upper edge. Fig. 1 also shows the suspension arrangement, the lips integral with the model are points of load application. Since the region about the engine location is rarely monocoque in construction the effective panel ends 16½ ins. from the tail. The level flight altitude, being the most common for civil planes off the ground, was the loading condition.

This was based on an assumed passenger monoplane of 7500 lbs. gross weight, with the following common characteristics:

C. G. .....at 30% of wing chord
C. P. .....at 40% of wing chord
Front Spar. .....at 15% of wing chord
Rear Spar. .....at 65% of wing chord

Weights:

Engine (600 hp.), radiator, water.....1250 lbs.
Gas and oil for 4 hrs.....1470 lbs.
Tanks 1 lb./gal. oil and ½ lb./gal. gas...130 lbs.
Fuselage and furnishings.....1250 lbs.
6 Passengers and 2 pilots at 200 lbs. each.1600 lbs.
Landing gear .....400 lbs.
Tail surfaces .....150 lbs.
Propeller and starter .....200 lbs.
Wings about .....1000 lbs.

The thrust load was estimated by assuming a cruising speed of 100 m.p.h. at ⅔ full throttle or 400 hp.

Since the L/D averages about 10 for a number of airfoils, the above estimated thrust load gives an incline of about 1–10 for the supporting wires at the spar points.

The actual study was confined to four cases: (1), without perforations; (2), with three round windows equally spaced; (3), with four round windows and a door; and (4), with perforations of the third case cut to filleted rectangular openings to compare with the more popular window shapes. Only the last two cases are of importance.

The model was suspended in a frame at the two spar points with interposed turnbuckles and dynamometers to check the balance of the model. Frequent readings were made to make sure that the dynamometers registered equal loads, and any deviation was corrected by the adjustment of the turnbuckles.

The drawing of the isoclinic lines was laborious because of the small optical field and the necessity of handling the model by sections, requiring careful matching for the final map. The Nicol prisms were rotated at 10° angles through 90° for the complete map, the

*Abstracted from a thesis by the author at the Massachusetts Institute of Technology.

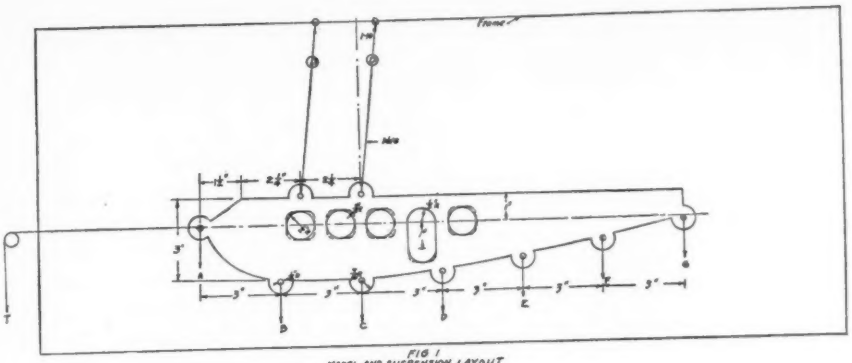


FIG 1
MODEL AND SUSPENSION LAYOUT
Scale - Half Size

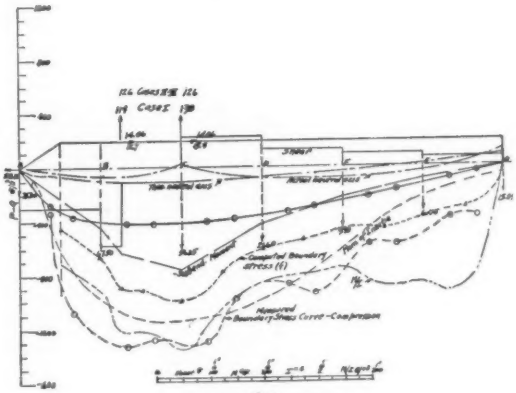
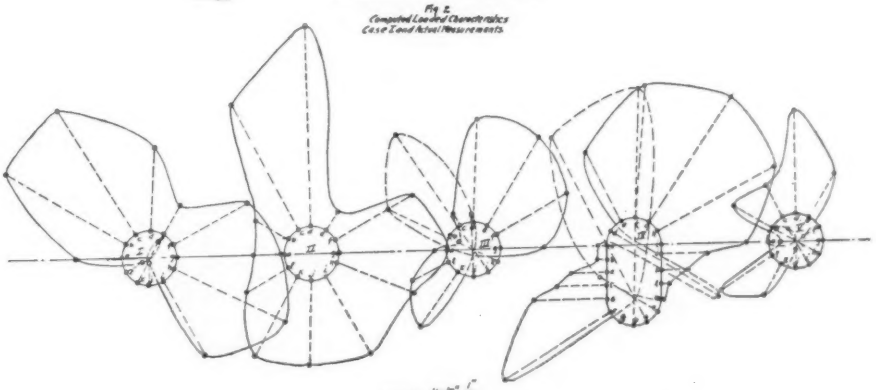
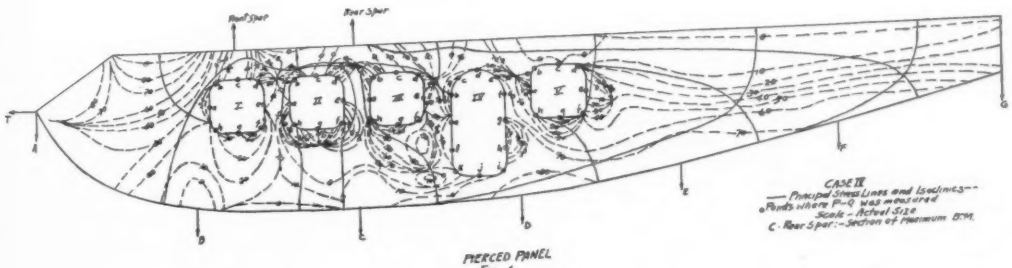


Fig 2
Computed Load and Characteristics
Case I and Actual Measurements



Scale = 1in/10° f"
Plotted from circumference
Holes actual size

Case III
Fig 3
Difference of Principal Stresses
measured at boundaries
—Tension —Comp.



PIERCED PANEL
Fig 4

lines of principal stresses being evolved therefrom. Lines of principal stresses passing through regions in which investigation was desired were selected and points of intersection with the isoclinics marked for measurement. Points around the windows were marked about every ¼ in. By tracing these lines and points on the model with a crayon, the values of the difference of principal stresses were obtained with the comparator.

Since Case I is a beam under a particular loading, the general beam theory could be applied to it and Fig. 2 shows the computed characteristics with the measured boundary stresses for comparison. The comparative features are the shape of the curve of compressive boundary stresses, the (f) curve and the neutral axes. The computed M/I curve must be multiplied by the distance y from the neutral axis for the fiber stress, both tension and compression being of the same magnitude by definition. The measured boundary stresses obviously were affected by the high local stresses of the lips. The actual neutral axis clearly indicates a point of zero stress where the shear changes sign. The abrupt shift at C, where maximum bending occurs, and the other deviations from the theoretical neutral axis are caused by the load pulls—a phenomenon that is well known through previous studies.

For the other cases the beam theory does not hold because the cutouts destroy the initial assumption of continuous longitudinal fibers in the theory.

Fig. 3 shows the boundary stress variations around the windows and doors for Case III. They are accurate enough to influence design.

Fig. 4 shows the isoclinics and lines of principal stresses for Case IV. Regions of high stress are shown by the crowding of the principal stress lines, usually occurring about points of neutralized stress. It is significant to note that these points occur in the region between perforations. They are situated between those crescents of high stress alternatingly tension and compression at the window boundaries. The curling of the principal stress lines around the openings is in accord with what is logically expected.

The purpose of this article is not to give a rigorously exact technical report, for that would be useful only for a more elaborate laboratory set up than was available at the time, but it is hoped that this preliminary treatment will create interest in a fascinating method of analyzing a very indeterminate type of aircraft construction. A rich field for investigation is of a complete fuselage with varying tail loads. Some experimenting with this model showed great divergence in stress intensities by distinct isochromatic disturbance throughout the panel when the tail load was appreciably altered, although the distribution change was not as marked. The various loading conditions of a plane, of course, suggest themselves as necessary problems for investigation.

Book Reviews

Growing Wings, by FILSON YOUNG; Michael Joseph Ltd., London, England, 1936; 180 pages, 6s.

Suppose the United States had a Secretary of Air of equal rank with other Cabinet officers; suppose this Secretary felt that it would increase his usefulness and the morale of his service if he learned to fly and maintained his own private aerodrome; further, suppose that he suggested to Sinclair Lewis, Walter Damrosch or Arthur Brisbane that they learn to fly and the proposal was accepted. This sequence would parallel in a large measure how "Growing Wings" came to be written. The Marquis of Londonderry while Secretary of State for Air of Great Britain, induced Filson Young, novelist, essayist, poet and musician to take flying lessons. During his period of instruction Mr. Young gave seven or eight talks from a radio broadcasting station describing his flight training and the first half of the book consists of these broadcasts.

In the second part of the book he gives a more detailed account of his emotions before and during his experiences and his impressions concerning the private pilot in England.

The book is intended to give prospective pupils some idea of what a course of flying is like, but some of Mr. Young's conclusions may act as a deterrent rather than an incentive. As might be expected from such a prolific writer and keen observer, "Growing Wings" demonstrates how a prosaic routine may be made into a book, even though there are evidences of duplication in some places. The Foreword by Lord Londonderry is probably the most important part of the book as it relates his various activities in connection with British governmental aviation which began shortly after the War.

Mussolini Aviatore, by GUIDO MATTIOLI,; Casa Editrice Pinciana, Rome, Italy, 1936; 342 pages, ill.; 30 Lire.

Although this work is written in Italian, the illustrations are so numerous and well chosen that readers who do not read Italian can follow the aeronautical career of Il Duce without break from 1921 when he became a pilot. For fifteen years Mussolini has been as much of an aeronautical enthusiast as any pilot who flys every day. He loses no opportunity to fly whenever and wherever he can and Guido Mattioli, the editor of *L'Aviazione,* has traced Mussolini's interest from 1909 when he was writing articles for the Italian newspapers.

In 1913 he took his first flight, and as editor of *Il Popolo d'Italia* he devoted special pages to aviation. Signor Mattioli has been able through his close connection with Italian aviation since its early development to interpret the background of the leader's interest, which has played such an important part in making Italy one of the great air powers.

Note on Effect of Cylinder Head Design on Detonation

C. F. TAYLOR, *Massachusetts Institute of Technology*
G. L. WILLIAMS, *Pratt & Whitney Aircraft*

(Received June 5, 1936)

IN the course of the development and subsequent use of the M.I.T. knockmeter [1] at the Massachusetts Institute of Technology, information on the effect of combustion chamber design on detonation has been discovered which seems worthy of attention.

The physical nature of detonation has been analyzed by C. S. Draper.[2] This work showed that the characteristic noise of detonation originates in pressure waves in the cylinder gases which result from sudden burning and very rapid rise of pressure in a portion of the fuel-air mixture. The frequency of these waves has been computed for the cylindrical form of combustion chamber, and has been found to agree with measured values.

The M.I.T. detonation indicator, or "knockmeter," is shown diagramatically in Figs. 1a and 1b. The cylinder element consists of a relatively thick diaphragm mounted in an assembly which screws into a threaded hole in the cylinder head. The diaphragm carries an aluminum cup-shaped armature located between the poles of an electro-magnet. A small winding is mounted on the inside pole in line with the armature. Pressure waves in the cylinder cause motion of the diaphragm which, in turn, moves the armature axially and varies the magnetic field surrounding the coil, which thus generates an electro-motive force.

The armature coil of the cylinder element is connected to a suitable amplifier, the output from which may be used to operate an oscillograph, or to deflect the needle of a galvanometer. The oscillograph records are useful for studying the frequency and wave form of detonation, while the reading of the galvanometer gives a measure of detonation intensity.

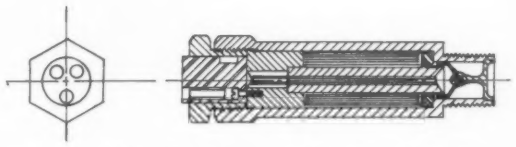


FIG. 1a. M.I.T. Knockmeter. Assembly of cylinder or "pick-up" unit.

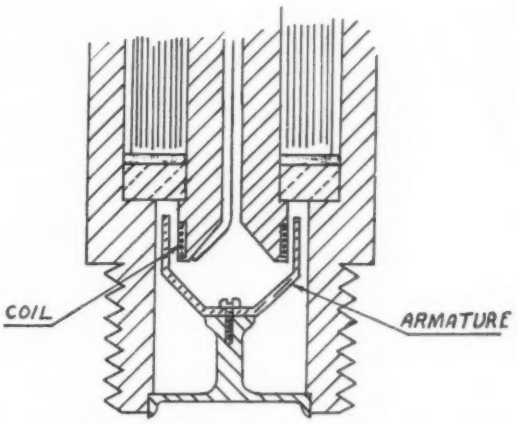


FIG. 1b. Detail of lower end of "pick-up" unit.

EFFECT OF POCKET IN CYLINDER HEAD

Fig. 2 is a diagramatic cross-section of a combustion chamber of the Cooperative Fuel Research engine. The operation of the detonation indicator with the cylinder element in the pocketed hole, which is designed to receive the "bouncing pin" type of indicator, was not quite what was expected, and it was tried in the side hole normally intended for the spark plug. Here

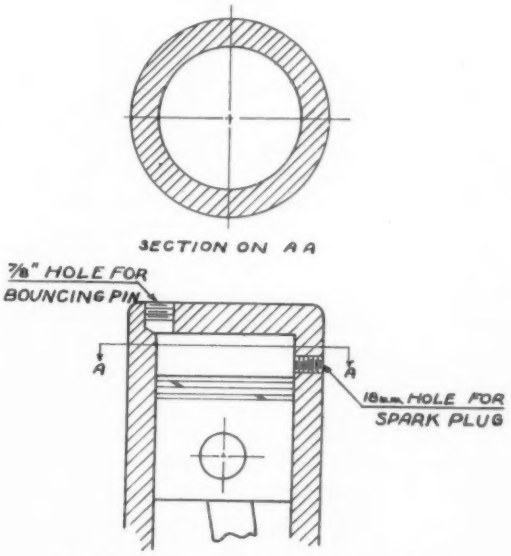
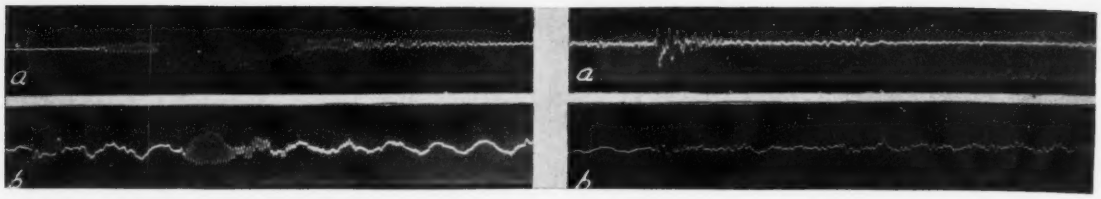


FIG. 2. Standard C.F.R. combustion chamber.

[1] C. F. Taylor, et al., *A New Instrument for the Study of Cylinder Performance*, S.A.E. Journal, Feb. 1934.

[2] C. S. Draper, *The Physical Effects of Detonation in a Closed Cylindrical Chamber*, N.A.C.A. Tech. Report 493, 1935.



Knockmeter unit in side hole (no pocket). Spark Plug in pocketed hole.

Spark Plug in side hole. Knockmeter in pocketed hole.

FIG. 3. Oscillograms taken with (a) Knockmeter in cylinder, and (b) Condenser microphone, constructed by W. M. Hall, E. E. Dept., M. I. T., suspended near engine.

the diaphragm of the indicator was very nearly flush with the combustion chamber wall. The spark plug was put in the pocketed hole intended for the bouncing pin. The results of this change were surprising. The compression ratio at which knock became audible was decreased by .55 units. Furthermore, the character of the knock was changed, being a much clearer, more penetrating sound.

Fig. 3 shows oscillograms from the detonation indicator and from a radio microphone located about one foot from the cylinder wall. The first group was taken with the spark plug in the pocketed hole and the indicator in the side hole, and the second group with the spark plug in the side hole and the indicator in the pocketed hole. The compression ratio was adjusted to give moderate knock intensity in each case. The effect of the pocket opposite the spark plug seems to be not only a substantial increase in the allowable compression ratio, but also a distinct change in the nature or mode of vibration of the gas in the cylinder. The resultant wave form is a combination of several frequencies giving a noise of much less penetrating power than the sound usually characteristic of detonation.

The curves of Fig. 4 show the effect of the size of the pocket on the compression ratio for incipient detonation for several fuels. The spark plug was in the side hole, and the pocket size was varied by screwing the detonation indicator element different distances into the pocket.

Since the pressure waves of the gas in the engine cylinder seem to be the chief source of the noise accompanying detonation, the sound intensity must depend, to some extent at least, on the accoustical properties of the combustion space. It would seem that proper analysis of combustion chamber shapes, together with experimental determination of wave forms, would divulge shapes of such acoustical properties that the creation and maintenance of sound waves would be discouraged. Thus, the noise resulting from detonation might be greatly reduced. Systematic study may reveal means considerably more effective than the accidental effect of the pocket described above.

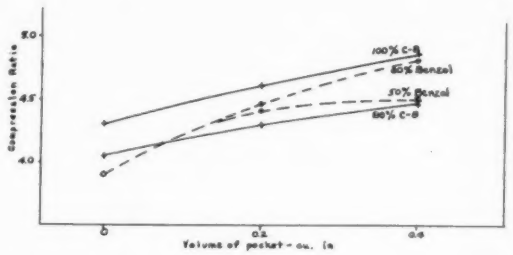


FIG. 4. Effect of size of pocket opposite spark plug on compression ration at which detonation becomes audible. C.F.R. engine at 900 r.p.m. (Note: Benzol and reference fuel C-8 in standard reference fuel A-3).

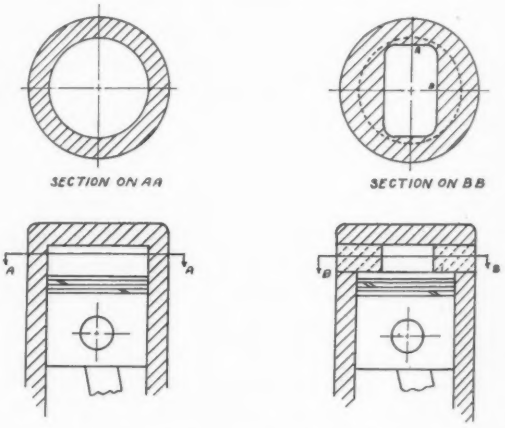


FIG. 5. *A*—standard. *B*—with aluminum insert.

OVERHEAD VALVE COMBUSTION CHAMBER

Fig. 5, (B), shows a modification of the C.F.R. combustion chamber which was made by inserting an aluminum block between the head and the cylinder proper. The cylinder height was so adjusted that there was only a very small clearance between the piston and the bottom of the aluminum block at top center. The compression ratio obtained was 5.7. The curves of Fig. 6 show a comparison of the oblong combustion chamber provided by this insert, with the conventional cylindrical combustion chamber, Fig. 5, (A). The location of the spark plug in the oblong

combustion chamber is very important. With the spark plug in position "A," at one end of the combustion chamber, the detonation characteristics are little different from those of the conventional cylindrical combustion chamber at the same compression ratio, 5.7. However, with the spark plug in position "B," at the side of the combustion chamber, the knock intensity at 5.7 compression ratio is equivalent to that of the cylindrical chamber at a ratio of 4.85. This is equivalent to a reduction of about 14 octane numbers in the anti-knock requirements of the fuel.

This important increase in allowable compression ratio by modification of the combustion chamber shape is probably a result of decreased time for combustion due to the more central location of the spark plug. The importance of combustion time in its effect on detonation has been shown by E. S. Taylor.[3] The effect is magnified by the reduction in spark advance required for best power with the spark plug in the central position.

[3] E. S. Taylor, *Importance of Auto Ignition Lag in Knocking*, N.A.C.A. Tech. Note 452, March 1933.

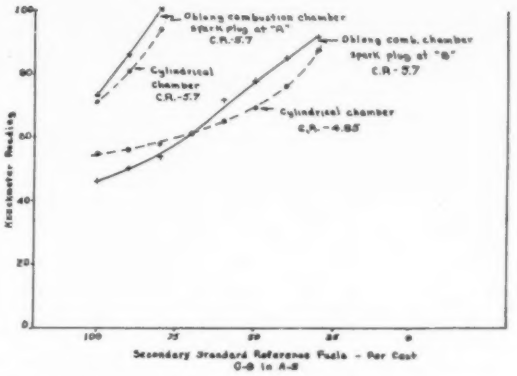


FIG. 6. Detonation characteristics of special oblong combustion chamber compared with characteristics of conventional combustion chamber (C.F.R. engine). (Note: Anti-knock values of fuels: C-8—77 octane, A-3—43.5 octane).

Aside from demonstrating the usefulness of a detonation indicator, these examples serve to show the possibilities of substantial increases in allowable compression ratio through modifications of combustion chamber design.

Book Reviews

International Organization in European Air Transport, by LAURENCE C. TOMBS; Columbia University Press, New York, 1936; 219 pages, $3.00.

From a vantage point as a member of the Communication and Transit Section of the League of Nations and a wide acquaintance with European air transport officials, Dr. Tombs has compiled a book which is invaluable as a guide to the organization of air traffic in Europe. It will be particularly helpful to those who are unfamiliar with the many international organizations having to do with the various activities of air transport in its various phases.

The historical background showing the relations that have inevitably existed between civil and military aviation in European countries is the result of thorough research and is well documented. That there has always been this close connection has always been well known although not always admitted. Whenever agreements which on their faces were strictly commercial had to be negotiated the political aspect always intruded to make the problem more complicated.

The legal difficulties of operating international airports that had to be surmounted are considered in great detail.

The expansion of air routes which will bring to many more countries the questions that have arisen to plague the operators of air lines of Europe makes this book a timely contribution which will be helpful to many countries which will have to consider the flight of foreign aircraft over their territory.

The old idea that the air is free is passing with the establishment of international air lines. Prohibited zones and corridors of approach are still barriers to this conception. In spite of the progress made in simplifying regulations and customs requirements there still remains much to be done before aircraft may be utilized with fullest advantages in air transport.

Dr. Tombs' conclusion is that "It is as clear today as it was in the first phase of the Disarmament Conference that an adequate measure of international organization with respect to both civil and military aviation will be reached only when governments are prepared to take the necessary political decisions. Lacking such international organization, the air peril will continue to disturb, or even terrify, the nations, and air transport itself will not have attained that degree of freedom which alone will enable it to serve Europe and the world."

The book contains an excellent Bibliography.

LESTER D. GARDNER

Schulversuche zur Fluglehre, by ERNST ROLLER; Carl Heymanns Verlag, Berlin, Germany, 1936; 104 pages, ill.; R.M. 4.60.

This book on "School Experiments on The Flight Theory," prepared primarily as a teacher's manual, gives illustrated practical experiments for the instruction of students of about the high school grade. The author maintains that such experiments are necessary and useful in instruction even if undertaken on a small scale.

Plain and simple language is used, the highly technical phraseology being reduced to a minimum necessary for the complete understanding of the relation of one experiment with another.

As the "theory of flight" is the youngest branch of physics now taught in schools, and as the science of aeronautics is progressing so rapidly, the book makes no claims for completeness, but should prove useful as a supplementary instruction book.

The book is divided into five sections as follows: (1) General Principles of Aeronautics, (2) Lighter-than-air Flight, (3) Heavier-than-air Flight, (4) Laws of Aerodynamics, and (5) Theory of Circulation.

Radio Echo Altitude Meter

E. F. W. ALEXANDERSON, *General Electric Company*

(Received April 25, 1936)

AN altitude meter for airplanes functioning on the principle of a radio echo from the ground was developed a number of years ago with the hope that this would become one of the ways in which radio would contribute to the art of aviation. After the results of this work were announced in 1928, the author, not being an aviator, did not feel justified in advocating the use of this method because the demand for such service should naturally come from the aviators. It is, therefore, an interesting indication that requests for further information on this subject have come from the Institute of the Aeronautical Sciences.

The radio echo altitude meter has a single tube radio receiver operated with an antenna which takes the form of a single wire trailing behind the plane. The receiver is so designed and adjusted that it radiates a wave towards the ground and simultaneously receives the echo reflection of this wave returning from the ground. The radiated and reflected wave combines into the characteristic pattern of a standing wave, with well defined maxima and minima which are directly indicated on an instrument dial.

In the tests which were made and which will be described later, the first positive indication of approach to the ground was given at an altitude of 600 feet, and it was found that by the guidance of this indication it was possible to navigate over rolling country and steep hills and depend upon receiving a positive warning signal when the ground is approached within 600 feet. If it is desired the system can be readily redesigned by changing the wave length so that the first warning will be given at a level of 1,000 feet, which is likely to be more useful for commercial aviation. Such a design also has the advantage that the characteristic maxima and minima of the standing wave will occur an even 200 feet apart; thus making a convenient scale for judging ground distances.

Fig. 1 shows the amplitude of the echo indications at altitudes between the ground and 1,000 feet. The successive maxima and minima increase in amplitude as the ground is approached. There is a maximum at 200 feet, a minimum at 400 feet; a maximum at 600 feet and a minimum at 800 feet, etc. The instrument thus distinguishes between the different levels by the amplitude of the swing of the needle. If it is assumed that a plane is navigating in a fog the pilot can get accurate information of the approach of the ground

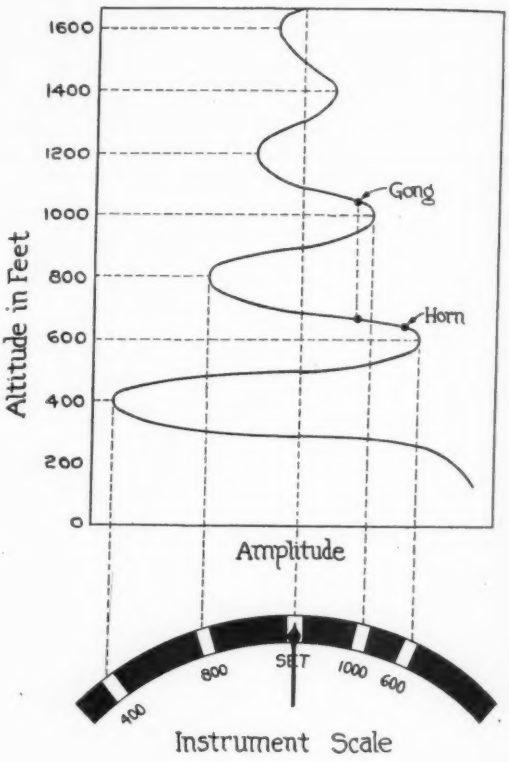


FIG. 1.

by observation of the instrument. It was found that the most practical method of bringing this to his attention was by a sound signal such as a gong which will ring when he crosses the 1,000 foot level. The next warning will be at the 600 foot level where the increased danger will be brought to his attention by the sounding of a horn. With the aid of these audible signals it should be possible to navigate so that the ground is never approached closer than 1,000 feet when the first signal is used as a guide and 600 feet with the second signal. Theoretically it should also be possible with the same means to navigate at a level of 200 feet, but this will probably not be practical except at the landing field where the pilot is guided by radio beacons.

The author herewith wishes to give credit to F. G. Patterson for the working out of the radio altimeter

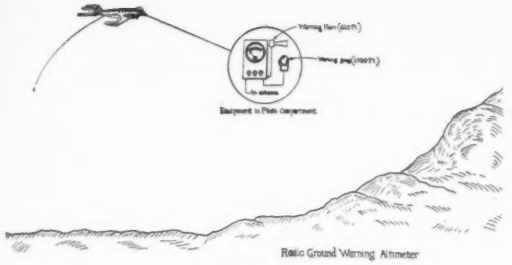


FIG. 2.

into a practical form and establishing, by a series of tests in the air, the best methods for its use. The following description by F. G. Patterson of his experiences in testing the radio altimeter will give an idea of its practical possibilities:

"The test equipment was installed in a cabin plane equipped with the necessary trailing antenna. Flights were made for the purpose of testing the operation under various adjustments as well as to get information on its possible utility in actual flying service. An idea of the method of adjustment and operation may be obtained from a description of a typical flight. After takeoff and attainment of a safe altitude the antenna is reeled out and the filament of the tube turned on. At any convenient altitude over 1,500 feet a turning adjustment is made. The correctness of this adjustment is indicated by the instrument pointer coming into coincidence with the mark labelled "set" on Fig. 1. As this adjustment is being made a variation of the pointer over a narrow range will be observed. This is due to reflection effects, of small amplitude, occurring when irregularities in the surface of the ground cause variations in the local altitude of the plane. The adjustment is so made that the range of variation is equal above and below the scale mark. The instrument is now ready for operation. As long as the plane cruises at 1,500 feet or higher the range of variation will be small and no further attention is needed except that it is possible that on long flights, extending over hours of time, an occasional check on this tuning adjustment might have to be made.

"Tests were made in the vicinity of Schenectady at a point where the Rotterdam hills rise steeply to a height of 1,000 feet above the Mohawk valley. After gaining sufficient altitude to adjust the instrument for proper operation the plane was flown across the valley at an altitude of about 800 feet and headed for the hills. The pilot was instructed to fly straight for the hills and to pull into a steep climb either when he heard the signal gong or when his judgment warned him that to continue without doing so would be dangerous. He was to fly as though unaware that the crest of the hill loomed ahead some 200 feet above. This test was made to simulate the situation in which a pilot is caught in conditions of low visibility over unfamiliar territory and is endeavoring to find a way out under the ceiling which is closing in. As the hills were reached after a level flight across the valley and the ground began to rise beneath the plane the gong would suddenly sound. Instantly the pilot would pull into a steep climb enabling the plane to clear the crest of the hill. This procedure was successfully repeated until the writer was convinced that this use of the equipment would be valuable as a warning of dangerous proximity to earth. Although the 600 foot warning point was successfully used in these tests, the feeling existed that the hill would have become uncomfortably close if we had been in a real fog. The conclusion was therefore reached that for the future an instrument which gave a first warning at 1,000 feet and an additional warning of increased danger at 600 feet should be recommended. The characteristics of such an instrument is illustrated in Fig. 1.

FIG. 3.

"Another method of operation was tested which may be described as the taking of "depth soundings." This method proved to be useful over relatively unbroken ground under conditions simulating low visibility. After adjusting for proper operation at 1,500 feet a gradual descent was made until the warning gong sounded. The pilot then knew he was 600 feet above local ground regardless of the reading of his aneroid barometer. The aneroid barometer incorporated in the instrument could then be set accordingly. This might be useful for flying over the sea in fog or at low visibility. It may be of interest to mention that the weight of the instrument used for these tests and illustrated in Fig. 3 was six and one-half pounds including the aneroid altimeter."

Problems of the Transoceanic Airplane

I. I. SIKORSKY, *Sikorsky Aircraft*

(Received May 19, 1936)

THE last few years have seen a considerable improvement in large, multi-engined flying boats, particularly in this country. The major reason for this is the development of long, over-water airlines by Pan American Airways. The excellent record of this organization which operated from Miami to the Panama Canal and major cities of South America cleared the way for the next important step—the pioneering of trans-Pacific flying during the year 1935.

Aviation is now prepared to extend this great step and to establish regular airline service across all oceans. Within a very few years one of the conventional ways of traveling to Europe will be by air in 24 hours or less on board a flying boat. Shortly thereafter, it will become possible to get to any point of the globe in 2 or 3 days. The encouraging results already achieved, and those we may expect in the near future, are made possible as a consequence of the general development and progress in various branches of aeronautical science and industry.

The object of this article is to discuss briefly the problems connected with the development and operation of a type of aircraft designed for transoceanic operations.

It is known that a modern dirigible is capable of carrying passengers across the ocean. Great credit is due the builders and flying crew of the "Hindenburg" for their excellent achievement. Besides this, some of the authorities of air transportation point to the many successful oceanic flights that were made with landplanes and consider that a properly designed landplane may be used to advantage for transoceanic travel. The author does not deny the possibility of the use of either of these types, but believes that the sum total of advantages definitely point to the very large flying boat as the most reliable and efficient type of equipment for long over-water voyages. As compared to a dirigible, a modern flying boat has about two times the cruising speed. The "Hindenburg" cruises at 78 m.p.h., while the S-42, a typical long-range flying boat, cruises at 162 m.p.h. This ratio is likely to remain unchanged. Nature placed a handicap on the lighter-than-air craft by requiring 400 to 500 cubic feet of gas to lift the load that can be carried by 1 square foot of wing area of a plane. The size of this article does not permit going much deeper into the comparison, but the author firmly believes that the flying boat is also superior from the standpoint of safety, economy and convenience of operation.

In comparing the flying boat with the landplane the advantages in performance, which are quite substantial in the small landplane, become less pronounced as ships

The S-42 flying boat used by Pan American Airways on its first transpacific flight in April, 1935.

TABLE 1

Effects of a vertical air gust of 25 ft. per second on a plane cruising at 150 m.p.h. (220 ft. per second). The change in angle of attack is

$$\Delta\alpha = (U/V)\ 57.3^\circ = (25/220)\ 57.3^\circ = 6.5^\circ$$

Action of Gust	Wing Loading	C_L Not Affected	α Not Affected	$\Delta\alpha$	α New	C_L Affected	Action of Gust in % of W
Downward	15	.261	+1.2	−6.5°	−5.3°	−.28	−107.5
	30	.522	+4.3	−6.5°	−2.2°	−.025	−4.8
Upward	15	.261	+1.2	+6.5°	7.7°	.80	+307.0
	30	.522	+4.3	+6.5°	10.8°	1.07	+2.050

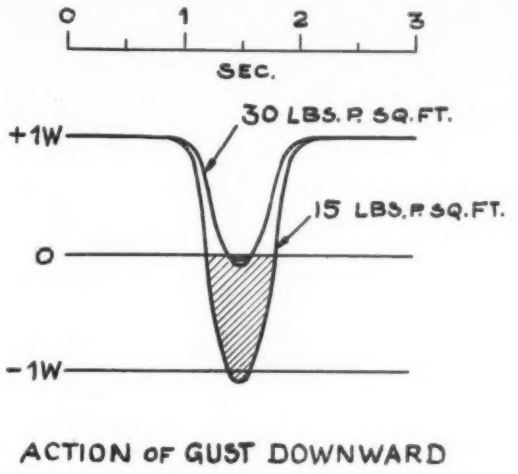


TABLE 2

The action of the downward air gust is graphically represented in this table. It was assumed that the plane would reach the zone of full velocity of the air gust within one-half of a second and would until then remain on a straight course. It may be considered that the undesirable effect of the air gust is represented by the area enclosed between the 0 lift line and the curves representing the lift of the wing with the two different loadings.

increase in size. The very large flying boat has nearly the same performance as a land transport of similar size and power, but the flying boat has important operating advantages in the possibility of using large harbors for terminals. The flying boat is also generally safer for the proposed service. This is not only in view of the remote chance of a forced landing in mid-ocean, but rather with respect to a more frequent hazard which may happen if the ship, after having crossed the ocean, should encounter fog or extremely bad weather which would make the landing at the terminal inadvisable.

Consider the case of a plane approaching New York under such conditions. The crew of a flying boat would have by far the best chances of overcoming such difficulties. While other aircraft would have to locate for their landing one of the few spots which are suitable, the flying boat has at its disposal along the whole shore line vast spaces of water such as Long Island Sound, Chesapeake or Delaware Bays and others. It was found that for every one square mile of airport area which is available for land aircraft between Boston and Norfolk, there are about 1,000 square miles of inland water spaces well adaptable to permit normal landing of a large flying boat in any weather. While the necessity for a landing on the open ocean is extremely remote with large aircraft of the proper type, yet if this were to happen, the crew of the flying boat has again considerably better chances not only to protect the occupants but also to save the airplane.

A transoceanic flying boat can easily stand a longer take-off and a greater landing speed because as a rule it will be operated from large open spaces of water and will at no time take off or land much above sea level.

One of the most difficult requirements is the range necessary. It is desirable that a ship with crew, equipment, accommodations and sufficient payload have a range of from 4,500 to 4,800 miles. Assuming that a well designed ship could cover this distance in 30 hours, flying at 50% power, this figure alone requires the carrying of about 7 lbs. of fuel and oil per rated horsepower. This in turn makes a heavy power loading necessary. There are also two important considerations necessitating a heavy wing loading in the transoceanic airplane. One is high aerodynamical efficiency at reasonably high cruising speed, which necessitates a high aspect ratio and a heavy wing loading; the other consideration is the great importance of giving full protection in flying in stormy weather. Both theoretical and practical studies prove that the influence of storms, which cause both discomfort to the occupants and heavy stresses on the machine, decreases considerably as the wing loading becomes higher. It can be seen from Tables 1 and 2 that of two airplanes flying under identical conditions at an equal cruising speed but loaded at 15 and 30 lbs. per square foot respectively, the effect of a gust is considerably more pronounced on the airplane with the lighter wing loading. The action of the vertical gust will produce an acceleration about twenty times as great in the lightly loaded airplane as compared with the one that has a heavy wing loading. An interesting confirmation of this idea is given by nature, as it was found that large birds flying over the ocean have a much heavier wing loading as compared to birds of similar size and weight that live on land. Because of this these birds have a remarkable ability to stay in the air with perfect ease for long periods, even in very stormy weather.

The nature of the proposed service requires a high degree of reliability in flight, considerably in excess of what would be sufficient for most other types of airliners which are operated over shorter distances and have emergency fields at their disposal. It appears necessary, therefore, to have at least four engines, and

TABLE 3

Plane	Gross Weight Approx.	Parasite Resistance of Boat Hull in b. hp. at 160 m. p. h.	Volume Available for Passengers and Useful load in Cubic Feet	Parasite Resistance per 1000 Cubic Feet of Volume in b.hp.
S-39	2 Tons	105	145	725
S-42	20 Tons	365	2,160	170
S-X	160 Tons	1,280	24,500	52

TABLE 4

Plane	Gross Weight	Parasite Resistance of Boat at Hull at 160 m.p.h.	Max. Rated Horsepower Available	Parasite Resistance of complete Boat Hull in % of Total Rated Horsepower Available at 160 m.p.h.
S-39	2 Tons	105	400	26.2
S-42	20 Tons	365	3,000	12.2
S-X	160 Tons	1,280	24,000	5.3

eventually six or more, and excellent flight and control characteristics with part of the power units out of commission. It is further necessary that all power units with their accessories, fuel and oil systems, as well as all major mechanisms of the flying boat, be accessible in the air for inspection and minor repairs. The long flying hours will require at least two shifts of crew on board.

All the factors that have been mentioned above and several others point toward a plane of fairly large size. The author believes that the smallest of the successful flying boats to be used for service after completion of the pioneering period will be of about 40 tons. Eventually, much larger ships will be seen.

Opinions have been expressed in the past that large aircraft become inefficient and that the so-called law of squares and cubes will not permit the construction of successful planes far in excess of the present size. Various investigations made on this subject showed convincingly that the facts are rather the opposite of this, particularly in reference to the flying boat.

Very successful results have been obtained with the S-42 Clipper, which has a gross weight of little more than 20 tons. What can be expected in the future from a flying Clipper of 160 tons? The useful load, performance and other characteristics in the larger boat would depend on the comparative structural and aerodynamical efficiency—in other words, on the proportional weight and parasite resistance of the component parts of the new airplane. A brief analysis would disclose in what direction the weight and resistance of the major parts would be changed if the plane were to have 8 times greater weight and power. The main parts involved would be as follows:

Wings and Control Surfaces. The structural weight per square foot would be substantially heavier, resulting in a heavier proportional weight of the wing in spite of the fact that in the larger ship it is possible to use a slightly heavier wing loading for similar take-off and landing characteristics. Profile resistance of the wing would be smaller because of the scale effect.

Power Plant Complete with Propellers, Fuel and Oil Systems, and Accessories. The structural weight of the engines can be considered as being the same in proportion to the power. The weight of the accessories, fuel and oil systems, instruments and controls will be lighter in a large installation. Parasite resistance will also decrease proportionately because large wings and a large body offer the possibility of better fairing of engines and other parts, including the possibility of eventually having all these parts enclosed inside the wing.

Pilot's Cockpit, Flying Controls, Radio, Automatic Pilot, Landing Lights, etc. Weight and parasite resistance decrease proportionately in the large plane.

Boat Hull and Side Floats. If proper attention is given to the design, the structural weight of the boat hull and side floats can be maintained substantially in proportion to the gross weight in the large plane. Proportional parasite resistance is considerably reduced. In the case under discussion, while the weight and power are increased 8 times, the resistance of the boat hull increases theoretically only 4 times, and actually still less, because of the scale effect and because the larger size permits a more refined shape and proportionately smaller entrances, windows, pilot's cockpit, etc. This considerable advantage in parasite resistance is accompanied by a marked improvement in the useful volume which will increase, not 8 times, but substantially more than that because in the larger boat it is possible to extend the cabins further in front and in the rear because of the ample head room. Tables 3 and 4 illustrate these facts by giving the resistance of the boat hulls of two flying boats that are now in service and the estimated data of a 160 ton flying boat.

The results of this brief analysis of these four items indicates that only in the first one is there a definite increase in structural weight per unit of area and therefore in percent of the gross weight. In all other items the structural weight may be kept under control or improved. The parasite drag is substantially decreased in all of them. Taking into consideration the fact that on a flying boat a major part of the power at cruising speed is absorbed by the parsite resistance, it can be readily understood that in the large ship there is a greater gain in efficiency due to economy in parasite drag than there is a loss due to slightly greater structural weight. This explains why the larger ship is definitely more efficient. This should not be considered as a suggestion for unlimited increase in size. But

there is no doubt that flying boats of 40 to 60 tons, and eventually much larger airplanes, will prove to be practical and successful equipment for transoceanic travel, and will permit the realization of greater efficiencies and better characteristics than can be obtained in smaller airplanes.

A large amount of research work on this subject has been completed by the engineering organization with which the author is associated, and the author is confident that it is possible now to produce a flying boat of from 40 to 60 tons with a range of more than 4,500 miles at a speed of not less than 160 m.p.h. This will permit maintaining a service across the North Atlantic without stops on a schedule of less than 24 hours. A flying boat of such a type, besides carrying a large crew, fuel and oil for the crossing, all equipment, and providing comfortable living accommodations, will carry a payload of about 10% of the gross weight. This figure is well in line with and probably higher than the corresponding one for high class steamers or railroad trains. Flying boats of this type would have staterooms with sleeping accommodations for from 30 to 50 passengers. Besides that, there would be a dining room, a galley, a smoking lounge, washrooms, ample space for luggage, and comfortable quarters for the crew to live on board. This would include individual staterooms for the captain and for two senior officers.

From 5 to 6 such flying boats would be sufficient to establish a daily service in both directions between the United States and Europe. If the 40 ton airplanes are used, they will be able to transport up to 210 passengers and 14,000 lbs. of mail in each direction every week.

A speed that will permit crossing in 24 hours is possible and also sufficient. For the success of a trans-Atlantic airline, a much higher speed will not be necessary for several years to come. But two other factors are important for real success. It must be a daily service in both directions. To make the airmail service really valuable it is necessary that a letter mailed from New York any day before noon would reach Europe the next afternoon and be taken within a few hours by local airmail to most any of the important cities. If this is not the case and an airmail letter must wait several days before the departure of an aircraft, the service across the Atlantic would lose most of its value except with respect to pioneering and study. The other factor is safety and regularity. In this respect the author is confident that the large flying boat if properly designed for the particular service will permit a transoceanic airline to be operated with a very satisfactory degree of safety and regularity.

The transatlantic air service is now a problem of the immediate future. It is one of the most promising and in several respects the most important of the air routes in the world. It is very desirable that American aviation, which leads the world in several respects, should also take the leadership in transoceanic flying.

Book Reviews

Aces and Kings, by L. W. SUTHERLAND; Angus & Robertson, Ltd., Sydney, Australia, 1935; 275 pages, ill.; 6s.

In the most unexpected places gems are found in books as well as mining. Normally a book by a Flight Lieutenant on the personalities and activities of No. 1. Squadron of the Australian Flying Corps operating in the Middle East would have little interest to Americans. But when in thumbing over the pages the reader stumbles on a chapter titled "Our Lawrence" and finds that this was the squadron which served as the "air force" of Lawrence of Arabia he is interested at once. And he will not be disappointed, for here is a vivid story of Lawrence's work stripped of all legendary romance, with particular attention being given to the uses "Sherif Aurans" made of aircraft in his maneuvering of his Arabian "irregulars," which numbered over 100,000 at times.

Having been his "aerial chauffeurs, his aerial lieutenants, his Arab impressers," the author provides what in an art closely related to aeronautics is called a "close up" of Lawrence. The services rendered by aircraft to the Bedouins in the campaign have probably never been as authoritatively written.

The book brought back memories blurred by time to one who has been privileged to fly over Palestine and the Arabian Desert, and who only a few years after the armistice landed and spent a night at one of the stations on the Railroad which carried the Faithful from Turkey and Syria nearly to Mecca, and which was the principal object of seventy-nine "tulip" raids of Lawrence. Even at that time, the wells which had been contaminated by the hurried interment of bodies were still covered with barbed wire.

The book closes with an account of the great "push" of Allenby which is picturesquely called the "Last Crusade." In two days during this action the "Aussie" squadron dropped three tons of bombs and fired 30,000 machine-gun rounds.

"Aces and Kings" will be another of the innumerable personal accounts of flying officers and squadrons which will give future historians their source material regarding the first war in the air.

LESTER D. GARDNER

Audels Diesel Engine Manual, by A. B. GREEN and R. A. ZOELLER; Theo Audels and Co., New York City, 1936; 292 pages, ill., $2.00.

Gives concise answers to many questions concerning the theory, operation and maintenance of the Diesel engine. Tells what the Diesel engine is, why it works, and how it functions. The book is of a handy size, is well illustrated with numerous diagrams, and should prove useful to those taking up Diesel engineering.

PAUL H. WILKINSON

Photogrammetry Meeting at Rochester

June 16-18, 1936

THE Institute of the Aeronautical Sciences joined with the American Society of Photogrammetry in sponsoring a session at the Summer Meeting of the American Association for the Advancement of Science, at Rochester, New York, on June 17th.

A Rochester Committee, whose members were Dr. Walter Clark of the Eastman Kodak Company, Carl Bausch of the Bausch and Lomb Optical Company, and Dr. Edward Hoffmeister of the University of Rochester, made plans for the entertainment of the members and guests of both organizations. After the morning session at which the papers were read, a luncheon was given at the Rochester Club to visiting guests by the Fairchild Aerial Camera Corporation. During the afternoon the group was shown through the factory and laboratories at Kodak Park. The Eastman Kodak Company entertained the members of both organizations at a dinner given at the University Club. Dr. C. E. K. Mees, Director of Research of the Eastman Kodak Company, expressed the appreciation of the Rochester members of the A.A.A.S. in having the opportunity of receiving such a large group of "photogrammarians", a word coined during the sessions. Col. C. H. Birdseye, past president of the American Society of Photogrammetry, and Major Lester D. Gardner, Secretary of the Institute of the Aeronautical Sciences, replied with appreciative remarks.

The Institute is particularly indebted to Dr. Henry B. Ward, Secretary of the A.A.A.S., and Dr. Hoffmeister, chairman of the local committee of the A.A.A.S., for the exceptionally complete arrangements which were made at the University of Rochester for the meeting.

About eighty members and guests attended the meeting on "Photogrammetry", which continued from 9:30 a.m. until 1:00 p.m. Major Gardner, in opening the meeting, expressed the appreciation of the Institute for the excellent cooperation that had been given by the American Society of Photogrammetry and asked Col. C. H. Birdseye, Chief of the Bureau of Engraving and Printing of the U. S. Geological Survey, to preside and present the speakers. Leon T. Eliel, Chairman of the meeting, who had arranged the program, was unable to attend.

The first paper, *"Photogrammetry in 1936"*, was read by Lieut. O. S. Reading, of the U. S. Coast and Geodetic Survey. An abstract of the paper follows:

Photogrammetry in 1936 resembles the Automobile industry in 1910 or radio in 1920 in that a large expansion of air photo mapping is probable during the next few years. Recent developments in airplanes, cameras, plotting machines and photo materials have made it practicable to greatly increase the amount and accuracy of information mapped while reducing costs. Very few Americans are acquainted with the type of large scale accurate maps with complete detail which the newer technique can supply. Rather they are accustomed to generalized compilations from a heterogeneous lot of poorly coordinated traverses, platts, reconnaissance surveys and sketches which are the best to be had for nearly three quarters of the area of this country. How little detailed knowledge we have about land and resources is indicated by tax equalization surveys of some fourteen cities in Connecticut made with the aid of aerial photographs. These disclosed so much unrecorded property that the tax rate was lowered an average of 29 percent, the grand list increased an average of 47 percent and the cities lifted out of financial difficulties.

The possibilities of air photo mapping are beginning to be appreciated. Already there has been organized the American Society of Photogrammetry with a membership of about 400 and an International Society of 19 nations. Many methods of mapping from the photographs are in use, ranging from simply piecing the photographs together to form a mosaic to complicated plotting machines costing over $50,000 with which the highest quality maps may be traced directly from the photographs. More than 200,000 square miles will be photographed in the United States in 1936. The various methods and projects now under way illustrate the advantage and flexibility of photogrammetry in meeting special emergency needs but they also demonstrate that it would be much more efficient to map the country as a whole by the best available methods rather than use emergency hand to mouth procedures.

Photogrammetry in 1936 delivers a variety of products, some of which will always be standard and some only expedients to give limited specialized information as promptly and as inexpensively as possible. First, there is the pair of aerial photographs under a stereoscope. If one has normal sight in both eyes, nothing equals such a combination for first-hand comprehension of the "lay" of the land unless it be an expensive, specially constructed relief model. Second, there is the mosaic of photographs pieced together to cover a larger area. Such a composite assists in visualizing some problems for which exact scale and position are not important. Care and skill is necessary to avoid considerable discrepancies and to obtain even color tone but usually mosaics can be made more rapidly and less expensively than line maps.

Then there are several methods by which perspective representation of the photographs can be changed to an orthographic or vertical projection in compiling line maps. One is continually being surprised with the flexibility with which the photographs lend themselves to these different methods, most of which are specialized to meet some particular requirement with the greatest efficiency under limitations of time and equipment. Thus, in the Tennessee Valley, property maps of the reservoir sites were made by measuring the elevations of the property corners and an occasional distance upon the ground. The scale and perspective corrections to the photographs were then computed with specially prepared slide rules and laid off on enlargements which

had been printed to a uniform datum. The corrected lines were then traced to form the property map. This process was found to be about three times as fast and one third as expensive as equivalent work with the transit and tape upon the ground.

Most of the planimetric maps (maps without contours) are made in this country by what is called the radial line method. The trace of the ray from the lens to the object to be located is shown on the photograph as a line radiating from its principal point (intersection of the lens axis with the photograph). The intersection of the lines radiating from the centers of two or more photographs of the object gives its map position free from perspective displacements, provided that the axis of the camera did not deviate more than a degree or so from the vertical as the photographs were taken. Expert photographic pilots and photographers can usually obtain photographs sufficiently good for this method.

Although air photo mapping heretofore has been the hobby of a few enthusiasts, it now appears that it may shortly attain a wider appreciation of its usefulness. Table I shows a list of the purchasers and users of the photographs of the State of Connecticut taken by the Fairchild Aerial Surveys in the spring of 1935.

TABLE I

Partial List of Purchasers and Users of Aerial Photographs of the State of Connecticut.

1. State Planning Board—Entire State.
2. State Highway Department—Entire State.
3. State Agricultural Department—Land Use Maps.
4. State Board of Fisheries and Game—Game preserve studies.
5. State Department of Forestry—Enlargements of Forests and general tree planting.
6. State National Guard of Camp Locations for training in military use of photographs of the locality maneuvered over.
7. Cities and Towns—Enlargements for tax inventories and appraisal.
8. Cities and Towns—Base for property index maps.
9. Utility Companies, Water, Electric and Telephone—For detailed information about areas served by them.
10. Local Engineers—For planning and selling local surveys; determining acreages.
11. Individuals for interest in photographs of their property and its surroundings, especially in connection with improvements of their property and adjustment of boundary disputes.
12. Local Hunt Clubs—Photo maps of their areas.
13. Lawyers—To assist in various legal disputes on property boundaries and damages.
14. U. S. Geological Survey—For revision of quadrangle maps.
15. U. S. Department of Agriculture—In connection with land acquisition.
16. Relief administration—Studies of watershed areas, stream pollution, rural electrification, industrial census.
17. Schools and Colleges—For courses in physical geography and surveying.

This table indicates something of the value to the whole country of a complete set of photographs made readily available to all at the reasonable costs of a wholesale job.

Table two shows the results of tax equalization surveys made with the aid of aerial photographs by the Municipal Service Company, an affiliate of Aerial Explorations, Inc.

It will be noted that the tax rate was decreased an average of 29% and the grand list increased an average of 47% as a result of these surveys. Such results may well mean the difference between bankruptcy and solvency to many cities in this country.

TABLE II

Results of Revaluations in Connecticut Municipalities by the Municipal Service Co., Inc., Hartford, Connecticut, After Aerial Photographic Surveys.

	Year of List	Acres	Grand List	Reduction as Tax Rate	% Increase in Grand List	Sq. Miles of Survey
Middletown, Conn....	1923	19838	21399292	30.25	.....	42.6
	1924	19010	30657031	24.	43.26	Aerial
Berlin, Conn.....	1924	15978	4528103	25.	.....	37.
	1925	15970	7637204	15.	68.66	Aerial
Rocky Hill, Conn....	1925	7717	2375298	20.	.....	14.2
	1925	7313	2633795	15.	52.98	Aerial
East Haven, Conn....	1924	4136	6978579	25.75	.....	12.6
	1925	4807	12772382	14.50	83.02	Aerial
East Hartford, Conn..	1926	8684	22975299	21.	.....	18.2
	1927	9149	30673327	15.	33.51	Aerial
Windsor, Conn.....	1927	16045	13159079	21.	.....	30.2
	1928	16196	15141199	20.	15.06	Aerial
Bloomfield, Conn.....	1927	16689	4902232	25.50	.....	27.3
	1928	15769	6155429	22.	25.56	Aerial
Windham, Conn.....	1928	13824	17742264	18.	.....	25.4
	1929	13241	23142347	12.	30.44	Aerial
Greenwich, Conn.....	1929	25410	121849243	19.50	.....	47.7
	1930	27220	192385940	12.	57.89	Aerial
Old Saybrook, Conn..	1929	7759	3627745	29.	.....	18.
	1930	8147	5379276	16.	48.28	Aerial
Old Lyme, Conn.....	1929	11876	2894890	20.	.....	26.4
	1930	13709	6293461	10.	117.4	Aerial
Stamford, Conn.....	1931	19848	143018462	29.70	.....	38.3
	1932	19445	143836387	26.	.58	Aerial
Danbury, Conn.....	1932	21839	32630700	38.50	.....	45.4
	1933	19230	45923800	27.	40.70	Aerial
Average Reduction...	....	.....	.....	29%	47.48%	

Most of our overlooked opportunities, our mistakes and failures, are due to making assumptions and generalizations from half truths and inaccurate information. Those who are working in photogrammetry in 1936 look forward to the day when any man may sit at his desk and visualize, with the aid of accurate, detailed, large scale maps and aerial photographs, any part of the country in which he may be interested; to the day when he may plan his actions precisely in accordance with the basic facts about the land and move with speed and certainty instead of being compelled to wait for expensive special surveys or muddle through with generalized half truths on many of his maps as at present.

Dr. Walter Clark, Assistant Director of Research of the Eastman Kodak Company, discussed "Materials for Aerial Photography". Dr. Clark did not prepare a formal paper but explained to the meeting the many problems which have been solved in the preparation of the highly specialized films and plates for use in aerial photography and gave a forecast of some of the new products which may be expected in the near future.

Dr. W. B. Rayton of the Bausch and Lomb Optical Company, presented a paper on *"Lens Requirements for Photogrammetry"*. Excerpts from Dr. Rayton's paper follows:

The first aerial photographs were naturally made with such ordinary hand cameras as were available but it immediately became apparent that such equipment was far from satisfactory. In military operations planes were forced to fly higher and higher as the effectiveness of anti-aircraft artillery was improved, and as the altitude of the flight was increased lenses of longer and longer focal length became necessary.

During the war the allied forces found it difficult to obtain lens equipment suitable for their needs, in part because of a lack of optical glass of suitable quality in sufficiently large pieces and in part because of special requirements as to image quality or lens performance that had not, prior to that time, been of sufficient importance to lead to suitable lens designs.

Since the war reasonably satisfactory lenses have become available but with the development of the practice of photogrammetry there has arisen the need for a lens surpassing anything that has hitherto been developed, to which reference will be made later.

The main properties of photographic lenses in which we are interested are focal length, relative aperture, angular field of view, and image quality. The factors that combine to determine the specifications of a lens are the altitude of the flight, the ground speed of the plane, the degree of fineness of detail that must be recognized in the photographs, the amount of territory to be covered by a single exposure, the vibration of the plane, the characteristics of the photographic emulsion and the character of the illumination.

The relative aperture of the lens must also be chosen as a compromise between conflicting and opposing requirements. Because planes travel at a high rate of speed and because they are subject to violent vibration, exposure times must necessarily be short. They cannot exceed 1/50 second and in most cases probably should be less. Exposure time depends on emulsion speed, illumination and relative aperture. In peacetime operations illumination is generally good. Little photography can be accomplished on cloudy days for the plane flies at an altitude that is above the usual cloud level. The emulsions used are high-speed panchromatic. With such emulsions and working in full sunshine, it would seem as if lenses of pretty low relative aperture would suffice, even though the exposure time is 1/50 or 1/100 of a second. But another fact operates to increase the required relative aperture, namely the need for filtering the light to cut out the blue end of the spectrum in order to decrease the effect of atmospheric haze. At best, the surface of the earth, viewed from a height of 10- 20,000 feet, presents but little contrast and it is very seldom that the horizon can be seen because of the interposition of haze. Yellow and red filters are employed effectively to reduce the effect of haze and to improve contrast. For civilian mapping work exposures can be made with a relative aperture of f: 8 and sometimes even less by confining the work to the most favorable hours of the day. In military operations, of course, it is impossible to confine the flying to conditions most favorable for photography, and pictures have to be obtained at all times of the day during which the equipment available will actually produce a picture, so that for military operations speeds as high as f: 3.5 have been used.

In ordinary photography relative aperture is also dependent on the depth of focus required. Aerial photography differs in this respect inasmuch as the lens is so far from the object plane that depth of focus is no problem.

Field of view is of fundamental importance inasmuch as it controls the amount of territory that can be covered at a single exposure for an image of prescribed scale of reduction. The limits are here set by lens performance which in turn depends on the skill or good fortune of the lens designer and on the optical glasses available to him. It is obvious that if the scale of reduction is not prescribed, the amount of area covered by a single exposure on a plate of prescribed size can be increased at will by increasing the altitude of the flight. As pointed out before, there is a practical limit to the height at which the plane can operate and there is a limit to the scale of reduction that is acceptable so that the photographer is here quite completely at the mercy of the lens designer.

Inasmuch as the value of an aerial photograph is directly proportional to the amount of information that can be obtained from it, it is obvious that the utmost refinement of definition is essential. Here is no place for soft focus, pictorial quality. The lenses operate under two conditions not commonly encountered in ordinary photography: First, in order to reduce haze they are used with strong yellow or red filters so that no blue light reaches the plate and the ordinary chromatic correction employed in photographic lenses is no longer appropriate. Attention should be confined to achieving the best possible union for light in the upper end of the visible spectrum from the green to the red.

The other condition is the necessity for the most complete freedom from distortion. In a lens that is afflicted with distortion linear dimensions in the image are not geometrically similar to the corresponding dimensions in the object plane in all parts of the field. Measurements made from photographs taken from lenses that exhibit distortion are in error unless the exact amount of distortion is known and allowance made for it. This would be a tedious operation and is regarded as impractical. Therefore every effort has been devoted to the design of lenses in which distortion is reduced to a vanishingly small amount over an extended field.

Distortion is a variation in magnification with distance of the object from the center of the field and this variation may be expressed in terms of per cent. If a lens has 0.5 per cent distortion at 30° from the center of the field, it means that the distance from the center of the image to the point corresponding to the 30° angle will be 0.5%, too large or too small depending on the sign of the distortion. In ordinary photography distortion that does not exceed 1% usually escapes notice and distortion less than 0.5% requires careful inspection to detect. Lenses have been designed for aerial photography, however, in which over a total field of 60 or more degrees the distortion nowhere exceeds 0.02%.

The desire to cover an extended territory with a minimum of flying time has led to the development of multiple lens cameras in which simultaneous exposures are made through one lens pointing vertically and a multiplicity of lenses pointing obliquely. Other cameras are single lens cameras. The multiple lens cameras are, for the most part, equipped with lenses of the order of 6 or 6.5″ focal length; the single lens cameras, lenses of 8¼, 10, 12 and 24″, the latter being intended more particularly for military operations where small detail must be detected from great altitudes. Reference was made to the desire on the part of the aerial photographer for another lens surpassing anything that he so far had. This should be a lens of 6½″ focal length that would cover a plate 9″ square representing an angular field of view of nearly 95° with no distortion, excellent definition and not too much decrease in illumination in passing from the center of the picture to the edge. This is the problem now before ambitious lens designers.

Col. C. H. Birdseye presented a paper on *"Map Reproduction"*, an abstract of which follows:

The National Mapping Plan, prepared by the Board of Surveys and Maps of the Federal Government, includes an item for the preliminary publication of planimetric maps (maps without contours), prepared from aerial photographs based on adequate ground control surveys, followed by an item for the final publication of contour maps. The plan contemplates the publication of the planimetric maps in three colors—black for the works of man, blue for the water features, and green for the woodland areas. It also contemplates the final publication of contour maps in five colors, adding to the features cited above, the contours in brown and the improved highways in red.

The Geological Survey proposes to publish the planimetric maps and the simpler contour maps by photolithography, involving photographing the original drawings by the wet-plate process, separating the colors on the glass negatives by painting out or cutting in (engraving on glass) the lines on the negatives, photo-processing the negatives direct to metal printing plates, and printing the maps in modern rotary offset presses. The Survey proposes to publish the most difficult contour maps by the copper plate engraving process, because careful records of

publication of similar maps indicate that closely spaced contours can be engraved on copper better, quicker and cheaper than on glass. Such publication gives a better impression of shaded relief, permits easier corrections on reprint editions, and results in plates which do not deteriorate from excessive humidity. Maps are not printed from copper plates or glass negatives, but the plates as well as the negatives are photo-processed direct to aluminum printing plates. Excessive corrections by either method makes publication of reprint editions quicker and cheaper by preparing new printing plates.

As the papers offered for presentation at the meeting appeared to require more time than planned, Colonel Birdseye omitted reading his paper which dealt in a most comprehensive manner with all the processes required for the production of maps. Instead, he had available for each member a mimegraphed copy and offered to send a copy to anyone interested in the subject.

Captain Louis J. Rumaggi of the Corps of Engineers, who is stationed at Wright Field, described the operation of *"The Multiplex Aeroprojector"*. An abstract of the paper follows:

The multiplex aeroprojector is a stereoscopic plotting instrument utilizing aerial photographs in the compilation of topographic maps. It is the simplest type of the various machines heretofore designed for this purpose based as it is on the principles of direct optical projection of the two overlapping photographs covering a certain area.

The anaglyphic principle is used in effecting separation of the two images which means that the photographs are projected in space in complementary colors and by using filters of like colors, worn over the eyes, only the red image is seen through the red filter and the green image through the green filter. The resulting projection then is an image in three dimensions as seen on an intercepting screen just as certain motion pictures appear when viewed through colored spectacles.

In operation, the apparatus consists of a bar from which are hung two or more miniature aerial cameras. The image is projected on a screen which can be moved in the three directions. There exists on the screen a mark which is moved about to touch the features of the earth as projected. Immediately below the mark is a drawing pencil which traces on the map sheet the outlines and courses of these features. Thus the courses of streams, the outlines of woods, the position and shapes of houses, the right of way of roads and railroads are placed on the map. The hill and valley shapes are shown as contours or lines of equal elevation above sea level and are drawn by moving the table while the mark, set at a fixed elevation, is kept in contact with the ground.

The photographic information is placed in the machine in the form of reduced transparent positive plates, which are made from the original negatives by an accompanying projection printer. The glass plates are in reality small lantern slides.

The cameras can be moved about on their supporting bar until they again occupy in space, to scale, the positions of the aerial camera at the moment of the individual exposures. Thus the effects of bouncing and pitching of the aeroplane on the photograph are accounted for.

The determination of these positions of the aerial camera is accomplished by making all portions of the overlap in the two photos come into stereoscopic fusion and the resultant moulded image of the earth's surface is then shifted about in space to fit it to the ground.

With this type of equipment it is possible to make maps of areas without the operator actually seeing anything but the photographs, and maps have been made in Ohio of portions of the state of Washington, without any of the operators having seen the area to be mapped.

The map thus prepared is usually a better one than could be prepared for the same cost by the methods formerly used.

Charles W. Collier of the U. S. Soil Conservation Service, presented a paper on *"Use of Aerial Maps in Soil Conservation Studies"*, an abstract of which follows:

Planning for soil conservation work necessitates a field by field inventory of physical conditions of the land and of its use. The most rapid, economical and effective method of obtaining such information involves the use of aerial photogrammetric maps. The preparation of such maps covering all areas in which work is to be undertaken has been established as a policy of the Soil Conservation Service.

The procedures being used in connection with such photogrammetric maps differ as between agricultural areas and grazing or mountainous areas. In agricultural areas, aerial photographs are obtained on a scale of about 3.17 inches to the mile. From one set of these photographs, detailed base maps are constructed at a scale of 4 inches to the mile. Erosion experts use another set of enlarged photographs as field sheets, breaking each photograph into area units of uniform slope, soil, degree of erosion and land use characteristics. The boundaries of these units are drawn directly on the aerial photograph in ink and are then superimposed on the photogrammetric base map. The resulting erosion and land classification map shows field by field all pertinent factors relating to land use and physical condition of the land, and is used in the planning of detailed soil conservation and land use reorganization measures.

In areas composed predominantly of grazing or mountainous land, photogrammetric maps are made from photographs on the scale of 2 inches equals 1 mile and compiled into precise mosaics at the same scale. These mosaics are used as field sheets in the mapping of erosion and the establishment of range carrying capacities. After being plotted on the field sheets, this information will be transferred to base line maps at the scale of the field sheets or smaller.

The economy and increased effectiveness obtained through the use of aerial photographs results from several factors, among which are the following: (1) speed and economy, (2) quantity of detail, (3) conditions of gully erosion can be determined directly from photographs and frequently the amount of sheet erosion appears directly in the photographs, (4) the photographs differentiate between cultivated, grazing and forest land, (5) photographic enlargements used as field sheets make possible the plotting of ground conditions by visual identification on the photograph without the use of plane table intersection.

In addition to the use of aerial photography in connection with its soil conservation planning work, the Soil Conservation Service has had certain topographic maps constructed by stereoscopic photogrammetric methods. Of these, the most interesting involves the preparation of a precise topographic map of the Boulder Reservoir as a basis for determining the amount of silt being deposited in the Reservoir through measurements made at regular periods.

At the end of the fiscal year 1937, the Soil Conservation Service will have contracted for aerial photographs of approximately 400,000 square miles. Ultimately, photographs will be needed by the Service of the entire area of the United States with the exception of certain mountainous and coastal plain areas. Such photographs are likewise needed by many other agencies. The National Mapping Program, recommended by the Board of Surveys and Maps and the National Resources Committee contains provisions for obtaining of such photographs. It is to be hoped that means can be found for the carrying out of this program.

Spark Control of Supercharged Aircraft Engines

E. S. TAYLOR, K. F. KU and W. P. KENNEDY, *Massachusetts Institute of Technology*

(Received June 16, 1936)

THE use of the gear-driven supercharger has completely changed the picture of the limitations on aircraft engine output. Without a supercharger the limit is, ordinarily, the maximum power which the engine can develop. This is limited by the mass flow of air which may be drawn through the inlet valves and by engine friction. By increasing the density of the incoming air, a supercharger may increase the limit upon the mass flow of air to such an extent that mechanical failure will occur at less than the maximum output. Thus the limitation becomes the endurance of the engine. Because of this change in limitation, highly supercharged engines may not be operated at full throttle at sea level. Present practice is to limit the inlet manifold pressure to some figure which is considered safe. This results in a power *vs.* altitude curve similar to the lower curve of Fig. 3. At some altitude called the "critical altitude" the supercharger will be just able to maintain this safe pressure. At higher altitudes the power falls off due to decreasing inlet density in a manner very similar to an unsupercharged engine. As altitude is reduced below the critical altitude, when manifold pressure is held constant by throttling, power decreases because of (1) increased exhaust back pressure and (2) increasing inlet temperature. The increase in manifold temperature is due to the fact that the ratio of outlet to inlet temperature in a supercharger running at constant speed is approximately constant, consequently an increase in inlet temperature will follow an increase in atmospheric temperature.

The reduction in maximum allowable power at low altitudes is becoming increasingly serious as the critical altitude of supercharged engines is increased. As indicated in the lower curve of Fig. 3, with a critical altitude of 15,000 ft., the available power at sea level is only about 82% of the maximum. With the increased wing loading of modern airplanes, the takeoff condition is becoming increasingly critical and available power at sea level, is consequently, of increasing importance. The situation is, therefore, rapidly becoming more acute.

There is a considerable rise in temperature of the air passing through the supercharger, and since it is necessary to throttle to maintain constant manifold pressure at low altitudes, an obvious remedy for the difficulty is to reduce compression by the supercharger by reducing its speed, or by using only one of two stages, or by the use of some form of cooler for the inlet air. All of these methods add considerably to the complication and weight of the power plant. It is, perhaps, worth while to examine the various limitations and see why it is that manifold pressure must be kept below a certain value.

Exceeding rated manifold pressure may cause engine failure due to any one or combination of the following: (1) detonation, (2) overheating, (3) preignition, and (4) excessive maximum pressures.

The Detonation Limit

In order to obtain best efficiency and output, internal combustion engines are ordinarily operated at the highest possible compression ratio. The limit of compression ratio is established by the detonation tendency of the fuel. Since detonation increases with increasing inlet pressure, it follows that the tendency to detonate should always constitute a limit on the permissible amount of supercharging *provided other variables remain unchanged.* If detonation does not limit inlet pressure, the compression ratio can be increased or a less expensive fuel can be used. It is quite possible to control detonation as inlet pressure is increased by changing some operating variable. At present its is common practice to increase the fuel-air ratio at full throttle to accomplish this result. This is, of course, an extremely wasteful and somewhat limited expedient. It is also not completely effective since fuel-air ratio is commonly controlled by the throttle position, and at sea level, severe detonation may occur with the throttle partly closed, and hence without benefit of mixture enrichment. In automobiles, spark advance is almost universally controlled from the inlet pressure. This method is much less wasteful than mixture enrichment.

In order to determine what the limitations on output would be with the detonation limitation removed by retarding the spark, a series of tests were made in the M.I.T. automotive laboratory on a single cylinder engine. It was desired to find the effect upon heat rejected to the cylinder walls and maximum cylinder pressure. The preignition limitation depends upon engine and spark plug design and was not investigated Tests were made on a single cylinder engine equipped with a Wright J-5 cylinder which was provided with a water jacket in order that the amount of heat rejected could be measured easily. Fuel was injected into the

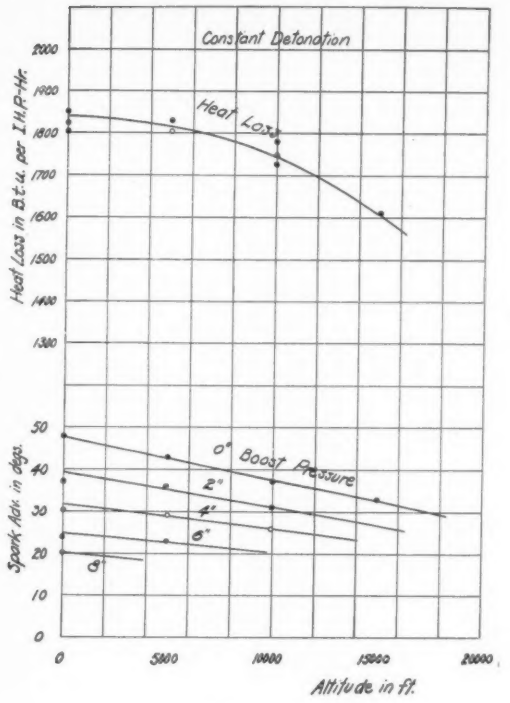


FIG. 1.

TABLE 1

Altitude	Atmospheric Temp. t_a	Atmospheric Pressure P_a	Inlet Air Temp. t_1	Inlet Air Max. Pressure P_1
sea level	59°F.	29.92"Hg.	174°F.	50.9"Hg.
5000 ft.	41°F.	24.89"	155°F.	43.0"
10000 ft.	23°F.	20.58"	136°F.	36.0"
critical altitude 15000 ft.	5.5°F.	16.88"	118°F.	30.0"

inlet pipe by means of a Bosch pump. One spark plug was used for ignition, the other spark plug hole being utilized for a knockmeter plug. A series of runs was made on this engine keeping a constant speed of 1600 r.p.m., fuel quantity for 98% maximum power, and exhaust pressure corresponding to various altitudes. Inlet conditions for the tests were established as follows: A supercharger with a critical altitude of 15,000 feet and a manifold pressure of 30" of mercury was assumed to give polytropic compression, $PV^{1.6} = \text{constant}$, inlet temperatures corresponding to various standard altitudes were calculated from these assumptions and the results tabulated in Table 1. It was assumed that throttling would change the inlet pressure but have no effect on inlet temperature. This contributes no appreciable error to the results. Runs were made under the exhaust pressure and inlet temperature conditions as established from these calculations and at varying inlet pressures. First a series of runs was made with fixed spark advance and constant (30") inlet pressure in order to determine the performance of the engine under the usual conditions.

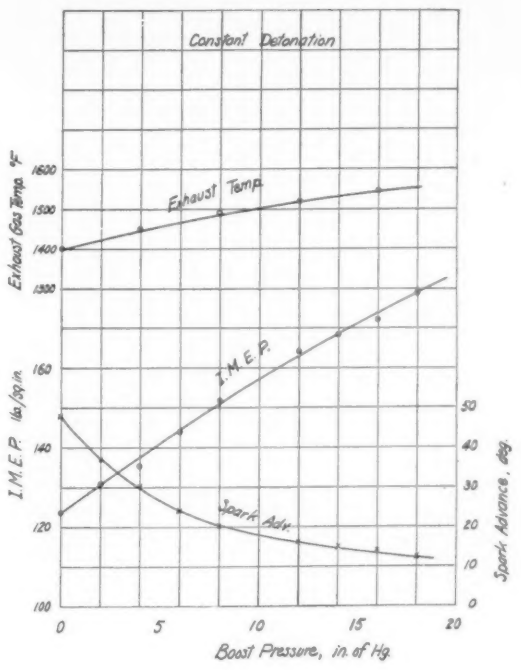


FIG. 2.

In all subsequent tests, detonation was measured by means of the M.I.T. knockmeter[1] and held constant by varying the spark. Fig. 1 shows the variation in spark advance which was necessary at the various altitudes and boost pressures.

HEAT REJECTION

The measured heat loss to the water jacket is also plotted in Fig. 1. The B.T.U. to the jacket per i.hp.hr. is not greatly affected by variations in boost pressure but decreases with increasing altitudes, probably due to the more complete expansion of the exhaust. It might be concluded from this test that the usual fear of overheating with retarded spark is unjustified. It should be remembered, however, that although the total heat rejected per i.hp.hr. is not greatly changed by boosting and retarding the spark, the heat to the exhaust valve may be. In order to check this a further series of runs was made at sea level in which a thermocouple was exposed to the exhaust gases near the point of exit from the cylinder. The results of this run are shown in Fig. 2. It is seen that the exhaust gas temperature increases some with increased boost and retarded spark. The amount of the increase is not, however, of sufficient magnitude to cause much fear of overheated exhaust valves. From the results of Fig. 1, the performance of a spark-controlled engine with constant cylinder head temperature was estimated

[1] C. F. Taylor, et al, *A New Instrument Device for Study of Cylinder Performance*, S. A. E. Journal, February 1934.

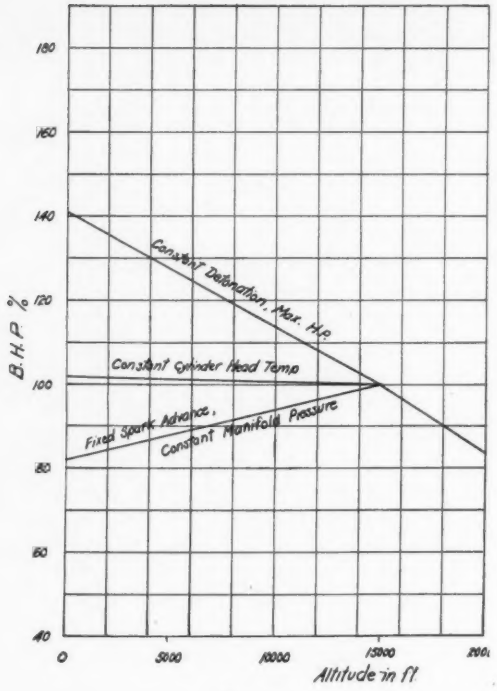


FIG. 3.

and plotted as the center curve of Fig. 3. The following variables were taken into account: (1) the change in heat input to the cylinder with altitude, (2) the chance in atmospheric temperature, and (3) the change in atmospheric density.

Average cylinder temperature was assumed to be 400° F.

Cooling was assumed to be proportional to the temperature difference and the 0.8 power of the density.

Airplane velocity was assumed not to vary with altitude. The highest curve of Fig. 3 represents the maximum power available, provided sufficient cooling can be obtained.

MAXIMUM PRESSURE

Pressure diagrams taken with the M.I.T. indicator[2]

[2] E. S. Taylor and C. S. Draper, *A New High Speed Engine Indicator*, Mechanical Engineering, March 1933.

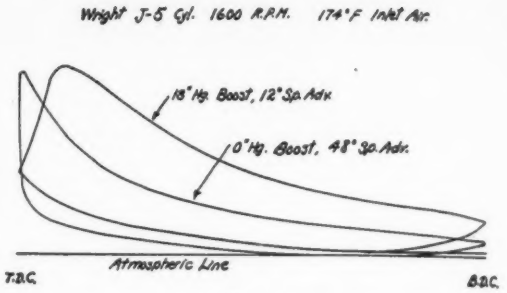


FIG. 4.

at the extreme sea level conditions are reproduced in Fig. 4. As expected from detonation theory, the maximum pressure is approximately the same even with the widely different conditions of power output and boost.

CONCLUSIONS

It may therefore be concluded that by employing suitable means of controlling the spark advance,

(1) Critical altitude power may be maintained down to sea level without increased cylinder head temperatures.

(2) If cylinder head temperatures are not excessive, power at sea level may be about 40% greater than power at a critical altitude of 15,000 feet.

(3) Stresses in the engine due to maximum gas pressure will not be increased by this method.

There is no apparent reason why the use of spark control should be limited to operation below critical altitude. It should be possible to obtain better cruising fuel consumption by increasing the compression ratio to the detonation limit for cruising manifold pressure and using a controlled spark advance at greater manifold pressures.

The simplicity of this method as compared with methods of reducing inlet temperature, its possibilities for very large increases in maximum sea level power as well as for reducing cruising fuel consumption, should recommend it for investigation in full-scale engines and in flight.

Orthoplane Theorems

A. F. ZAHM, *Library of Congress*

(Received June 1, 1936)

Summary

THE author assumes as obvious (1) that a suitably powered airplane can support itself directly by its propeller thrust, and (2) that in hovering with all its control surfaces in propeller slipstreams it can be securely poised by their use.

He then mathematically proves that a hovering aircraft cannot exert a dynamic lift exceeding its propeller thrust. Next he shows that per unit thrust a travelling airplane supports about the same gross weight with its wings inside as with them outside the propeller wash.

Preface

In this text the word orthoplane means an airplane adapted to fly straight up from rest in still air. A common type has all its control surfaces in propeller streams. Many such planes have been patented and some flown, at least in model form. A suggested example is shown in Fig. 1. The available thrust is assumed to be more than strong enough to support the machine when pointed straight upward, either coursing a vertical path or hovering. By hovering is meant flying dynamically without through-air travel.

Too often inventors assume that orthoplanes can hover in still air with a weight exceeding the propeller thrust. They say the lift of propeller and wing combined can exceed that thrust. The doctrine is invalid and should not be used for design or promotion purposes. Motionless wings can divert, but cannot generate, momentum. Indeed, they partly waste it.

Lift of Stationary Orthoplane

The weight dynamically supported by an airplane equals the rate of downward momentum it imparts to the air. If m, v, are the mass per unit time and mean axial outflow speed from a stationary airscrew, mv equals in magnitude the thrust maintaining the slipstream. In general the momentum flux mv is diverted by the assumed fixed wings through an acute angle i; hence the ensuing wing force has at most the component $mv \sin i$ across stream and $mv\,(1 - \cos i)$ along stream, as is well known.

The following theorem is now to be proven: a hovering airplane cannot exert a dynamic lift exceeding its propeller thrust.

If the thrust inclines at an angle of θ to the horizon, it has a vertical lift $mv \sin \theta$; the above cross-stream

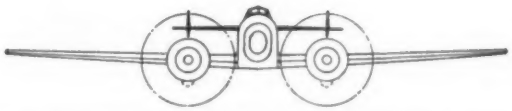


FIG. 1. Racing Orthoplane. Empennage and ailerons in slipstream; thrust $\geq$ gross weight

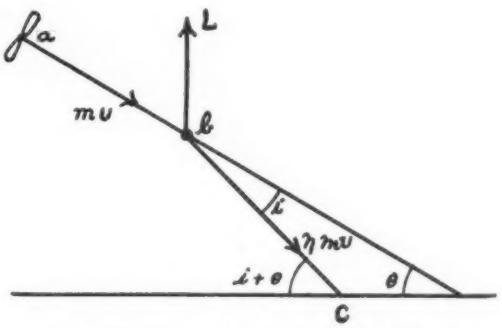


FIG. 2. Slipstream along ab deflected along bc; resultant of airscrew lift and wing lift at b is $L = \eta mv \sin (i+\theta)$

wing force has a lift $mv \sin i \cos \theta$ and the along stream wing force a lift $-mv\,(1 - \cos i) \sin \theta$. Their sum is

$$L = mv \sin (i + \theta) \qquad (1)$$

This cannot exceed mv. Therefore the whole aerodynamic lift of a hovering aircraft cannot exceed its propeller thrust. *Q. E. D.*

One notes that $L = mv$ when $i + \theta = \pi/2$, viz., when the deflected stream goes plumb downward. No hovering aircraft can have more aerodynamic lift. In general, L should be less because of friction or guide losses. These entail a reducing factor on the right side of Eq. (1). It may be defined as

$$\eta = L/mv \sin (1 + \theta)$$

and is always less than one. It is the ratio of the diverted to the initial momentum, and expresses the lifting efficiency of the hovering craft. Therefore Eq. (1) can be written

$$L = \eta\, mv \sin (i + \theta) \qquad (1)\text{a}$$

as indicated in Fig. 2.

Then why throw the slipstream against fixed wings if no gain of lift ensues? Mainly to let the craft hover more nearly horizontal or fly more slowly. The truth is that an orthoplane can hover without wings when pointed upward, supported by its screws and poised

by its tail unit. This unit can be fashioned to exert three-moment control; e.g., by making the flippers turn at will oppositely or identically while the rudder works as usual. Such an airplane however is but a freak helicopter.

Orthoplane wings are needed not for vertical but for horizontal flying. They may be of a large or of a small type. Large wings are useful for slow flight or dead-stick landings. A very swift orthoplane can be made with narrow fin-like wings for holding ailerons but too small for dead-stick landings. It could land like a helicopter supported by its screws. A racer of this type could fly vertically at fair speed, and horizontally at over 500 miles an hour.

The above formulas assume untrammeled flow. With external flow-baffles the lift of an air borne craft may exceed the propeller thrust. For instance a flatboat with side and end flanges dipping in the water can float on air supplied by a propeller whose thrust is indefinitely small. Trammeled-flow airplanes, however, are not treated here. The subject is broached in the writer's article on *"Elements of Theoretical Aeromechanics,"* which appeared in the Journal of the Franklin Institute, March, 1912, p. 261.

Lift of Travelling Orthoplane

In the afore-treated still-air hovering the flow consists of a propeller jet diverted vertically downward mainly by the fixed wings. The flux of downward momentum $\eta\ mv$ equals the lift; the drag annuls the forward component of the propeller pull. If now the diverted stream is made to lean from the vertical, so must the resultant air force, thus entailing through-air travel of the craft. This is the ordinary state of airplane flight in which the machine may incline any amount from the vertical, and the lift may greatly exceed the thrust.

It appears therefore that an airplane, of whatever ingenious design, cannot take off vertically from rest unless endowed with a thrust equal to its weight; but that so endowed it may fly along a slope with surplus thrust available for acceleration or travel speed.

Now assuming the propeller axis alongwind, the slipstream uniform, the wing-propeller interference negligible, one may prove that in steady flight with a given thrust T, and a given incidence, the wing lifts substantially the same when wholly in the propeller wash as when wholly outside. For, if the subscripts i and o denote inside and outside, $L_i/T = (L/D)_i$ and $L_o/T = (L/D)_o$. Since T is given as the same in both cases, clearly

$$\frac{L_i}{L_o} = \left(\frac{L}{D}\right)_i \Big/ \left(\frac{L}{D}\right)_o \qquad (2)$$

At any fixed incidence $(L/D)_o$ is known to increase but slightly with moderate speed increments; hence $(L/D)_i \approx (L/D)_o$[1], when $L_i \approx L_o$, or the wing lifts substantially the same inside as outside the wash.

Both cases show the same air speed against the wing and same thrust-work per mile over ground. In the o case the thrust power and travel speed are greater; in the i case the lesser travel speed allows slower landing, a desideratum at times.

If only part of a wing is washed it obeys Eq. (2) and the argument therefor. Hence with a given thrust this part lifts no more within than without the wash.

The more general case for a turbulent slipstream has been treated by able writers and need not be considered here. It involves many items entailing collectively no large practical consequences.

Practicability of Orthoplanes

The mechanical feasibility of orthoplanes, like that of helicopters, will doubtless be understood without proof. The usefulness of both remains for long experience to show, and the experience is still accumulating. Whether or not the orthoplane has useful possibilities, it can undoubtedly be made to fly at any speed from zero to well beyond the highest yet attained by any racing plane. Some notice of its dynamic theory therefore has seemed permissible.

It is noteworthy that the suggested orthoplane, Fig. 1, differs from well known practical airplanes only in having its ailerons in slipstreams and its thrust exceeding the gross weight. Well tried commercial engines are competent to hang it in the air by its screws. The control surfaces should, of course, be so placed as to remain constantly in the wash. The ailerons can be of full wing length; the wing span can be much reduced in high-speed types.

[1] This relation seems to be indicated by experiment; e.g. Wieselsberger, *Ergebnisse der Aerodynamischen Versuchsanstalt,* zu Göttingen, Lieferung 1, p. 115.

Editorial Note: Dr. Zahm here, perhaps intentionally, presents propeller designers with a new problem. What sort of propeller can give static thrust enough "to fly straight up from rest" and yet be suitable to fly "horizontally at over 500 miles an hour."

J. C. Hunsaker.

The Teledeflectoscope

W. KLEMPERER, *Goodyear Zeppelin Corporation*

(Received May 25, 1936)

DURING the erection of the airship MACON an unusual instrument system was developed for the measurement of small elastic deformations of a very large structure under conditions of difficult access. Since this system may have applications in the testing of large airplanes or of bridges and tall buildings, it may be of sufficient interest to be described here.

As the name is meant to imply the instrument serves to measure the flexure of long beams from a remote observation station through a telescope. The principle of the method is illustrated in Fig. 1. I is an index mark on a target card fastened to the beam B at the terminal point at the far end of the bay. L is a lens fastened to the beam at the point where its camber is to be measured. S is a scale fastened to the beam at the near end of the bay. The lens is of such optical power that it projects a virtual inverted image of the target pattern upon the plane of the scale S and extending in breadth beyond the edge of the scale. A mirror M is fastened somewhere in the vicinity of the scale and so adjusted that it reflects the image of target and scale towards a convenient observation station. Here it is picked up by a telescope T.

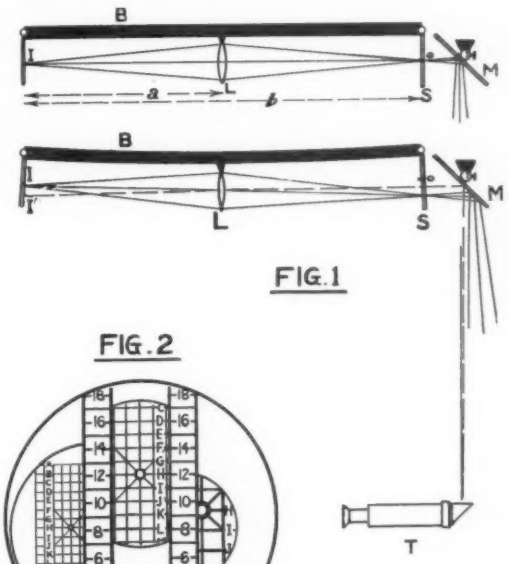
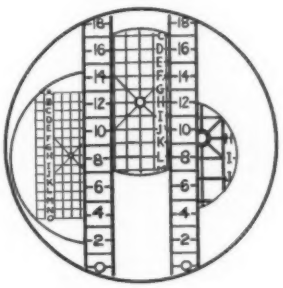


FIG. 1

FIG. 2



Instead of a single index line, a graduated pattern is convenient as it extends the measurement range for a given length of scale or size of mirror. The displacement of any index line against the scale after application of loads, shows the change of camber at L magnified in proportion to the distances b/a. To pick up the same index line through the central area of the lens before and after the application of loads may require shifting the telescope slightly. A different index line I' may be picked up without telescope movement. It is possible to read deflections in normal and lateral directions by providing two scales at right angles and an index pattern of lines at right angles to each other. Twist can be determined by mounting two lenses at station L, adjacent to each other.

The instrument lends itself well to measuring deflections at more than one intermediate point along the bay. For this purpose individual lenses are installed at each such point. A convenient system for three stations consists of a central midspan lens so aligned that it casts its target image between two narrow parallel scales and two quarter-span semi-circular lenses so mounted that they cast their respective images just outside these scales. Thus one sighting operation gives three readings on a pattern appearing in the telescope as shown in Fig. 2.

Where the structure to be investigated is not initially straight, prisms are mounted next to lenses so as to refract the light rays around obtuse corners. Targets are then illuminated by sodium light to avoid chromatic dispersion.

A moveable lathe carriage with a universal azimuth and elevation movement makes a convenient telescope mount and a periscope prism on the telescope is a useful accessory.

A Note on Beams Under Combined Side and Axial Loads

H. W. SIBERT, *University of Cincinnati*

(Received May 9, 1936)

THERE are several good methods for the stress analysis of a beam under combined side and axial loads. One is the analytical method outlined in Niles and Newell's *"Airplane Structures,"* and another is the graphical method given in H. B. Howard's *"The Stresses in Aeroplane Structures."* Designers may find it easier to apply the method given below than either of the above-named methods. Niles and Newell's formula for a beam under combined axial compression and uniformly distributed side load (see Fig. 1) is

$$M = \frac{D_2 - D_1 \cos L/j}{\sin L/j} \sin \frac{x}{j} + D_1 \cos \frac{x}{j} + wj^2, \quad (1)$$

in which

$$j^2 = EI/P,\ D_1 = M_1 - wj^2, \text{ and } D_2 = M_2 - wj^2.$$

If we let $D = M - wj^2$, Eq. (1) can be written as

$$D = \frac{D_2 \sin x/j + D_1 \sin (L-x)/j}{\sin L/2j}, \quad (2)$$

because $\sin L/j \cos x/j - \cos L/j \sin x/j = \sin (L-x)/j$.

If we let $D_{1/2}$ stand for the value of D at the middle of the beam, the substitution of $L/2$ for x in Eq. (2) gives us

$$D_{1/2} = \frac{D_1 + D_2}{2\cos L/j}, \quad (3)$$

because $\sin L/j = 2 \sin L/2j \cos L/2j$.

Moreover, if we let $D_{1/4}$ stand for the value of D at the left quarter point, the application of Eq. (3) to the left half of the beam gives us

$$D_{1/4} = \frac{D_1 + D_{1/2}}{2\cos L/4j}; \quad (4)$$

while the application of Eq. (3) to the right half of the beam yields

$$D_{3/4} = \frac{D_{1/2} + D_2}{2\cos L/4j}, \quad (5)$$

in which $D_{3/4}$ is the value of D at the right quarter point.

Formulas for D at the eighth points can be obtained by applying Eq. (3) to the quarter spans. For example

$$D_{1/8} = \frac{D_1 + D_{1/4}}{2\cos L/8j}, \quad (6)$$

in which $D_{1/8}$ is the value of D at the eighth point nearest the left end of the beam. However, it is usually not necessary to calculate the values of D at the eighth points.

With the five values D_1, $D_{1/4}$, $D_{1/2}$, $D_{3/4}$, and D_2, we can plot the curve of D for the entire beam. The corresponding curve for M can be found by merely shifting the x-axis down a distance equal to wj^2 measured to the scale of D, because $M = D + wj^2$. The minimum moment and the points of inflection can then be found.

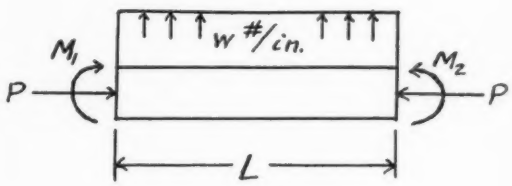


FIG. 1.

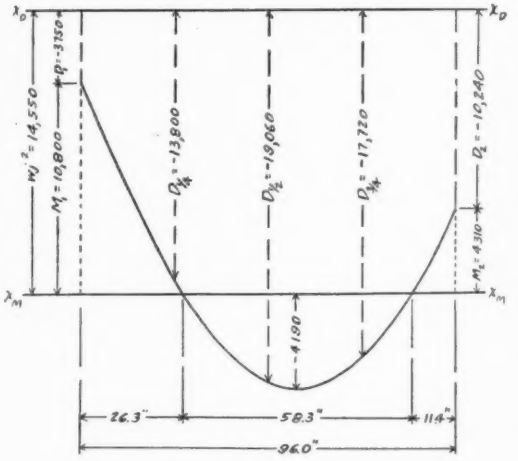


FIG. 2.

Let us apply this new method to an actual example. Suppose we have a beam in which $M_1 = +10{,}800$, $M_2 = +4{,}310$, $P = 3{,}150$, $w = 9.0$, $L = 96.0$, $I = 3.92$, and $E = 1{,}300{,}000$. Note that $j^2 = 1{,}617$, $L/j = 2.39$, $wj^2 = 14{,}550$, $D_1 = 10{,}800 - 14{,}550 = -3{,}750$, and $D_2 = 4{,}310 - 14{,}550 = -10{,}240$. Then from Eqs. (3), (4), and (5) we have

$$D_{1/2} = \frac{-3{,}750 - 10{,}240}{2 \times 0.3670} = -19{,}060,$$

$$D_{1/4} = \frac{-3{,}750 - 19{,}060}{2 \times 0.8267} = -13{,}800,$$

$$D_{3/4} = \frac{-10{,}240 - 19{,}060}{2 \times 0.8267} = -17{,}720.$$

To plot the curve for D, lay off D_1, $D_{1/4}$, $D_{1/2}$, $D_{3/4}$, and D_2 above or below the x_D axis according as they are + or − (see Fig. 2). Draw a smooth curve through these five points. The x_M axis is now drawn

parallel to the x_D axis and at a distance wj^2 below it (measured to the scale of D). The curve now gives moments directly when measured from the x_M axis. Moreover, the points of inflection are at the intersection of the curve with the x_M axis (see Fig. 2).

The same procedure can be used for combined axial tension and uniformly distributed side load. The only changes in Eqs. (3), (4), (5), and (6) are that the cosine becomes the hyperbolic cosine and each D is now $M + wj^2$ instead of $M - wj^2$.

Letter to the Editor

June 15, 1936

To the Editor
Journal of the Aeronautical Sciences
Rockefeller Center,
New York City

The trend of modern aircraft engine design has been steadily toward higher compression, in view of the obvious advantage of reduction in weight for a given power and the desire to obtain peak loads for take-off and single engine performance. This trend has resulted in an increased requirement for anti-knock ratings in aircraft engine fuel which has now arrived at a point where 100 octane fuel is being expected and promised. Granting that the performance of the carbureting engine is correspondingly enhanced by fuel of high anti-detonating properties, it must be borne in mind that limits are beginning to make themselves felt and that we should not assume that anti-knock ratings can be increased indefinitely or that anti-knock rating alone is all that is required to permit increase in the compression of carbureting engines.

It should be recognized at this time that the increase of anti-knock rating in gasoline has been at the sacrifice of raw material and at the expense of additional processing which becomes increasingly costly as anti-knock ratings rise. Likewise, such factors as cylinder head temperatures are beginning to form limitations, or at least problems for the engine designer. Heretofore, the anti-knock ratings have progressed from a normal rating of around 60 to the fighting grade of 87 without the necessity of manufacturing specific chemical compounds. The rise from 60 to 73 was accomplished by the oil industry by merely selecting crudes and segregating their distillates for aircraft use. The material thus selected generally forms a base to which lead may be added to the extent of less than 3 c.c. per gallon to produce the higher ratings. Cracked gasolines, which have formed the basis of the higher anti-knock grades for motor car use, have not been available for aircraft use since such gasolines cannot pass the accelerated gum test, which is to some extent a measure of the gum forming properties of the fuel. In view of the relatively small requirements for aircraft operation, the production of such fuel has been inconsequential so far as the oil industry is concerned, which deals in quantities of the order of 400,000,000 barrels of gasoline per year. In fact, although it is recognized that some day the aircraft requirements will be substantial, most companies have entered into the field for sentimental or advertising purposes rather than for profit.

The oil industry's primary function is to extract petroleum from the earth, separate it into marketable components—gasoline, kerosene, gas oil, lubricating oils, fuel oils, etc.,—with a minimum of processing and distribute these standard products to a nation-wide market. The most important function of the oil industry is to supply the automotive trade, which it does with remarkable precision and at remarkably low cost. Anywhere in the country the motorist may fill his tank with gasoline which will vary only a few percent in boiling range or quality. The chief factor which makes this service possible is the volume of business. With wide distribution of refineries, pipe lines and terminals, the oil industry can readily sell gasoline in large quantities and make a profit on prices which are the lowest in the world. When it comes to aircraft fuel, the mere fact that it is a specialized product, has no general distribution, and no volume, necessarily means that the cost of such fuel will be higher. The more specialized a fuel is, the more processing required, the less it utilizes a base commodity extracted from crude, the greater will be the expense. As octane values rise above, say, 90 C.F.R. and at the same time requirements for the accelerated gum test are maintained, the more the industry must depart from its regular business to produce this fuel. The manufacture of iso-octane and other synthetic fuels will be expensive primarily because of lack of volume. Sooner or later every product in the industry must carry its share of overhead and distribution. If the highly specialized synthetic fuel is to be utilized in small quantities all over the country, the real cost of producing it and distributing it will be startling.

The present insistence on anti-knock values, it may be pointed out, has brought aircraft fuels up from 73 octane to 100, therefore why not higher? This reasoning fails because the problem of increasing the octane in the low brackets is much simpler than in the high brackets. The former can be done by the addition of lead, but since the lead content is limited and since we obtain diminishing returns with increasing quantities, the use of lead alone is relatively ineffective in making the highest octane fuels. In spite of the amount of advertising of 100 octane fuel and of the synthetic types, there is very little of this really available and its production still constitutes a considerable mechanical problem although there is ample knowledge and sufficient raw material for such production if it can be made profitable.

Gasoline is a natural series of hydrocarbons segregated according to volatility by rather simple processing. In recent years the advent of the cracking process has made available a larger supply by altering the boiling ranges of heavier stocks.

The manufacture of iso-octane, or the like, however, is really a chemical procedure involving definite reactions of hydrocarbons using gas or gasoline or other products as a source of hydrogen and carbon. These methods of producing engine fuels must not be confused nor the problems involved be considered alike. On the one hand the only major requirement is to produce a material of given boiling range—on the other a definite chemical compound must be produced.

It seems to me that the engine designers are not viewing the problem of high octane gasoline with sufficient seriousness. We appear to be embarking on the development of engines requiring fuels which must be made by chemical synthesis rather than by distillation; this must necessarily demand a new cost structure and introduce new problems of distribution and storage. For instance, if wide distribution were accomplished by merely storing a few drums of special gasoline at emergency fields against possible use, the gasoline may deteriorate so as to be worthless when required, whereas with usual gasoline the turn-over would be sufficient to preclude such occurrence.

The oil industry will have to develop and operate new processes and add new ramifications to its refining plants. Heretofore it has been more like the lumber business which concerns itself with cutting timber and making planks. To add synthetic processes for the manufacture of specialized gasoline would mean that it must extend its processing beyond the plank stage into cabinet making and the manufacture of furniture.

I see considerable difficulty in tuning up for large production of the highly specialized fuel for, although it can be made from natural gas or cracked gas, and by means of thermal or catalytic reactions, the equipment cannot be brought into existence immediately. If such fuels are to be used for war time purposes it behooves us to go slowly in the manufacture of engines until an adequate and wide-spread supply is available.

It is the purpose of this letter to point out the foregoing circumstances which bear on future development and to suggest that opinions be obtained from authorities in engine design, the oil industry, and the chemical industry so that we may achieve a sense of proportion which will permit a realization of the relative difficulties to be encountered in the change of engine design and engine fuel. This leads me to ask a few questions to form a basis of discussion.

1. What are the relative difficulties and costs in producing 73, 87 and 100 octane gasoline suitable for aircraft engines?

2. What is the cost of equipment and the overall yield and operating cost of a plant to manufacture iso-octane or its equivalent at a capacity of 1000 bbls. per day?

3. How many such plants are proposed and how many are actually in existence?

4. What is being done to increase the production of such fuels?

5. What will be the distribution and storage problems?

6. What will be a fair cost for 100 octane fuel if it is made to share overhead and normal costs in the same manner as other refinery products?

7. What would be the daily requirements of gasoline for, say, 4000 military airplanes in time of war?

8. At what point will the difficulties of using high octane fuels and maximum allowable engine temperatures make it advisable to consider seriously the development of the ignition compression engine?

LUIS DE FLOREZ,
New York City.

Book Reviews

Die Luftwaffe der Gegenwart, by GEORG W. FEUCHTER; E. S. Mittler & Son, Berlin, 1936; 64 pages, ill.

This book is primarily an introduction to military aeronautics for volunteers of the German air force. Tactical and operation problems are omitted, as they require information outside the scope of the book's purpose.

There is a popular review of the organization of a modern air force, and its historical development before, during, and after the War. The complex duties of the air force in national defense are discussed briefly and there is a statistical comparison of German and Allied losses during the aerial combats of the World War.

The book is well illustrated by pictures of many types of aircraft and engines.

Deutsche Jugend, fliege!, (Fly, German Youth), by DR. FRITZ BRAND; Aschendorffsche Verlagsbuchhandlung, Münster in Westfalen, Germany, 1936; 124 pages, RM 1.90.

This brief book by Dr. Brand reviews the gliding activities in Germany from the time of the Versailles Treaty, which, in prohibiting the construction of airplanes in Germany, provided an incentive to start anew at the point where Otto Lilienthal left off.

Today gliding is the leading sport in Germany. Models of gliders are tested before full scale construction or flights are attempted. Studies of bird and insect flight are being made, and it is predicted that flights in airplanes propelled by muscular power will be attempted. The influence of meteorological studies on the advancement of the sport, especially those of Dr. Walter Georgii, are discussed, and Wolf Hirth's book on "The High School of Gliding" is said to have become a necessary part of the equipment of every glider pilot.

The importance of training young men and boys in the construction and flying of gliders and glider models is greatly emphasized, preparing them, as it does, for future training in the construction and operation of motored machines.

The book is well illustrated with photographs of famous German gliders and glider pilots, and short descriptions of outstanding flights are given.

The book concludes with a brief review of the history of flying from the time of Archytas, a Greek of 400 B.C., to that of Otto Lilienthal, and the recommendation that aviation should be made an integral part of the education of the youth of Germany.

Institute Notes

The Collier Trophy for 1935

Donald W. Douglas, Past President and a Fellow of the Institute, was presented with the Robert J. Collier Trophy by President Roosevelt at the White House on Friday, July 3d. Mr. Douglas was awarded the trophy with the following citation:

"To Donald W. Douglas, for the outstanding twin-engined commercial transport airplane. This airplane, by reason of its high speed, economy and quiet comfort, has been generally accepted by transport lines throughout the United States. Its merit has been further recognized by its adoption abroad, and its influence on foreign design is already apparent. In making this award, recognition is given to the technical and production personnel of the Douglas organization."

The Collier Trophy has been awarded annually since 1916 *"for the greatest achievement in aviation in America, the value of which has been thoroughly demonstrated by actual use during the preceding year."*

The Daniel Guggenheim Medal which has been awarded to Dr. George W. Lewis is given *"for notable achievement in the advancement of aeronautics."* The Sylvanus Albert Reed Award, the recipient of which is to be selected later this year, is given *"for a notable contribution to the aeronautical sciences resulting from experimental or theoretical investigations, the beneficial influence of which on the development of practical aeronautics is apparent."*

The Royal Aeronautical Society

As the Journal of the Aeronautical Sciences does not print advertising it cannot reciprocate the courtesy of the Royal Aeronautical Society in printing an advertisement regarding the Journal. Any members of the Institute who wish to apply for membership in the oldest aeronautical society in the world may obtain information regarding such membership from the Secretary of the Institute. Subscriptions for the Journal of the Royal Aeronautical Society, the price of which for American subscribers is £2, 4s, 6d may be sent direct to the Royal Aeronautical Society, 7 Albemarle Street, London W. I., England.

Visitors to the Institute

During the past few months many foreign visitors have called at the Skyport. Major Charles C. Turner of London, Charles Dollfus of Paris and Otto J. Merkel of Berlin were visitors who arrived on voyages of the "Hindenburg." Major Turner, who is the aeronautical editor of the London Telegraph, flew over many of the American air transport routes and gained a comprehensive idea of the operation of our air lines. Mr. Dollfus, who is Curator of the aeronautical museum in Paris and is one of the best known French lighter-than-air specialists, returned after a two day stay in New York. This was his fifth crossing of the Atlantic by airship. Mr. Merkel, who is a director of the "Weser" aircraft company of Bremen, Germany, will visit many of his friends in this country.

Prince Louis Ferdinand of Germany, who is now with the Deutsche Luft Hansa, spent several weeks observing the operation of American air lines. Prince Louis, after several years with the Ford Company in Detroit, is now engaged in air transport operations in Germany. Pierre Janet, French pilot, was taking delivery from the Sikorsky company of flying boats to operate in West Africa. Dr. Gustav Lachmann, who has been associated with F. Handley Page in the development of slots, spent a holiday in the United States which was largely occupied in flying. Dr. Ing. Heinrich Hertel, Technical Director of the Ernst Heinkel airplane company, accompanied by Ing. Erich Kleinemeyer, who is also with the same organization, are now on a trip to the Pacific Coast. F. R. Banks of the Shell Oil Company and W. E. Rootes of Rootes Ltd., of London, were also visitors. Commander James Bird, one of the founders of the Supermarine company and now a Director of The Supermarine Aviation Works (Vickers) Ltd, was spending a holiday of several weeks in this country, visiting aviation and other friends.

Meeting of the Pacific Coast Section

Eighty-eight members and guests of the Institute attended a dinner held by the Pacific Coast Section at the Hollywood Roosevelt Hotel on June 13, 1936. About twice that number attended the technical session, devoted to flying boats and seaplanes, after the dinner.

Three short papers of general resumé type were presented by members of the Consolidated Aircraft Corporation engineering department: "Trends in Flying Boat Design," by T. M. Hemphill, "Development and Design of the Stressed Skin Wing," by T. P. Hall, and "A Few General Remarks on Hulls and Floats," by H. I. Mandolf. The first two papers were delivered by Prof. K. D. Wood in the absence of the authors. Mr. Mandolf's description of the use of motion pictures of landings in a heavy sea to obtain the angular accelerations which a wave may impart to a boat proved to be of exceptional interest.

Schuyler Kleinhans of the Douglas Aircraft Company gave a paper on "Possibilities and Problems in the Design of Very Large Flying Boats" which caused lively discussion until well after midnight:

An equation for the speed for maximum lift-drag ratio was developed using the performance parameters defined by Oswald in N.A.C.A. Technical Report No. 408, and an additional parameter l_δ defined by $l_w = l_\delta \ W^{\frac{1}{3}}$, where l_w is the wing loading and W the gross weight, i. e.

$$V = \frac{14.85}{\sigma^{1/2}} \left[\frac{l_\delta^{\,2} \, W^{\frac{2}{3}}}{A.R. \ e \ C_{Dp}} \right]^{\frac{1}{4}}$$

This speed was shown to correspond to a value of Λ of 63.1

The gross weight for any value of Λ was then shown to be

$$W = \frac{(\Lambda A.R. \ e)^{3/2}}{C_{Dp}^{\,3/2} \ l_\delta^{\,3} l_t^{\,6}}$$

Hence the gross weight for optimum cruising speed would correspond to $\Lambda = 63.1$, and the maximum possible weight would correspond to $\Lambda = 75$.

Taking representative values of the parameters for a large flying boat; namely, aspect ratio (A.R. = 10), airplane efficiency factor (e = 0.81), parasite drag coefficient ($C_{Dp} = 0.20$), maximum overall propulsive efficiency ($\eta_m = 0.75$), and $l_\delta = 0.7$, curves of optimum speed, landing speed, span, length,

wing area and thrust power loading were drawn against gross weight. It was shown that the speed increases faster than the weight up to approximately 2500 tons.

Taking a particular case as an example it was shown, for fifteen pounds per brake horsepower, and 70% power for cruising, that the maximum possible gross weight was approximately 7 million pounds and the optimum weight 3 million pounds. The cruising speed was then 200 miles per hour for the maximum case and 235 miles per hour for the optimum case.

Basing the analysis on the 3 million pound design the author proceeded to show that the maximum speed would be 305 m.p.h. at sea level, the landing speed with flaps 127 m.p.h., and the landing speed after a 3000 mile flight 115 m.p.h.

Other characteristics were given as: span 550 feet, wing area 30,000 square feet, wing root chord 85 feet, wing root thickness 16 feet; length 375 feet, beam 40 feet; maximum lift-drag ratio 18, range 4800 miles; takeoff time 2½ minutes, takeoff distance 4¾ miles; average rate of climb 600 feet per minute, and average ceiling 12,000 feet.

Four power units of 50,000 hp. each would turn 5-bladed propellers of 60 foot diameter at 280 r.p.m. It was pointed out that the static thrust would be insufficient for taking off unless overdiameter propellers, or better still, overbladed propellers, were used. This would make an ideal cruising and climbing propeller when operated at full torque and reduced revolutions.

Weight items were given as:

Weight empty	1,500,000	pounds
Crew (100) and personal effects	25,000	"
Passengers (500 @ 170 pounds)	85,000	"
Baggage (500 @ 100 pounds	50,000	"
Cargo	340,000	"
Fuel & oil	1,000,000	"
Gross weight	3,000,000	pounds

The author stated that such a flying boat making four trips per week could transport as many passengers across the Atlantic as the latest and most luxurious liner, requiring only one daylight day or over-night to make the crossing, at fares less than for first-class steamship service.

The cost of such a flying boat was estimated at 20 million dollars—12 million for the boat proper, 7 million for the power plants, and 1 million for the propellers.

International Rep-Hirsch Prize

The International Rep-Hirsch Prize, awarded by the Astronomical Society of France (Societe Astronomique de France) for the most outstanding contributions to the practical developments of rockets, has been awarded jointly to Mr. Alfred Africano, author of "The Design of a Stratosphere Rocket" which appeared in the June 1936 issue of the Journal, and to the American Rocket Society. It is the first time the prize has been awarded to an American or to an organization, as previously the prize had gone to European experimenters. It was last awarded in 1931, when it went to Hermann Oberth, the noted German rocket experimenter.

The Award, of 5000 francs, was provided by Robert Esnault-Pelterie, French airplane manufacturer and aeronautical engineer, and Andre Hirsch, French banker. It is awarded by a committee appointed by the Societe, which examines the work of experimenters in every country impartially. Mr. Africano's share was for original mathematical analysis of the results of the American Rocket Society's experimental program, and designs for a high-altitude rocket based on those results.

The American Rocket Society, in announcing this award, gave full credit to John Shesta, a young New York mechanical engineer, for most of the Society's technical achievement. Until this year he was chairman of the Society's experimental committee. He is now President of the Society.

Luncheon to Wakefield Team

A luncheon was arranged by the Institute on June 26th for the British and French contestants who had come to this country to fly their models in quest of the Wakefield Cup and the Admiral Moffett Trophy at the International Championship Model Airplane Meet at Detroit.

The members of the British Team were B. K. Johnson, Chairman of the S.M.A.E. (Society of Model Aeronautical Engineers), team manager; J. C. Smith, Competition Secretary of the S.M.A.E.; Harry York, British Press Representative; J. B. Allman; Alwyn Greenhalgh; D. Fairlie; H. A. Jones; A. A. Judge; and R. Copland The ages of the team members range from 33 to 11.

The French representative was André Vincre, from Paris.

Group Captain T. E. B. Howe, British Air Attache; Colonel Frank P. Lahm and others extended a hearty welcome to the guests, which was replied to by the leader of the British Team and André Vincre.

A cable was read from Lord Wakefield. The following reply was sent:

"The Institute of the Aeronautical Sciences and guests, at a Luncheon honoring the British Team of model plane flyers visiting the United States in quest of the Wakefield Cup and the Admiral Moffett Trophy send felicitations to you whose splendid generosity is so largely responsible for making the trip possible. These young men promote international good will and are welcome here as representative of the coming generation of air men.

Institute of the Aeronautical Sciences"

After two days of entertainment in New York the party left for Detroit with Lieutenant Alden (U.S.N. retired), Chairman of the Model Committee of the Contest Board of the National Aeronautic Association.

Personnel Opportunities

The Personnel Bureau serves organizations seeking to employ aeronautical specialists as well as individual members. The Bureau has been the means of arranging several very successful connections for members.

Any member or organization may have requirements listed without charge.

Available

Design engineer wishes to make new connection. Fifteen years' military and commercial aircraft experience in England and America. Would prefer technical post where knowledge of skin-stressed metal structures and aerodynamics could be used to advantage. Thoroughly familiar with Army and D.C. requirements. Graduate aeronautical engineer, London University, 1922. Write Box 46, Institute of the Aeronautical Sciences.

Recently graduated Student Members of the Institute wishing to secure some connection in the industry have forwarded to the Institute complete biographies of themselves and records of their school work. It would be appreciated if members or organizations offering employment to this type of personnel would write Box 47, Institute of the Aeronautical Sciences, stating their requirements.

Exchanges

The Institute exchanges the Journal with many other aeronautical periodicals. They are kept on file at the Skyport in Rockefeller Center, New York City, where members may read them. As readers of the Journal may wish to subscribe to some of them, a list of these periodicals with their addresses is published here. Information regarding subscription prices may be secured from the Secretary of the Institute.

Aero, Maneesikatu 2, Helsingfors, Finland.

Aero Digest, 515 Madison Ave., New York City.

Aeronautica Argentina, Velez Sarsfield 57, Cordoba, Argentina.

L'Aeronautique, 55 Quai des Grands-Augustins, Paris, France.

L'Aerophile, 7 Rue Saint-Lazare, Paris, France.

The Aeroplane, 175 Piccadilly, London, W.1, England.

L'Aerotecnica, Via delle Coppelle 35, Rome, Italy.

Les Ailes, 77 Boulevard Malesherbes, Paris, France.

Aircraft Engineering, 2 Bloomsbury Place, London, E.C.1, England.

Air Law Review, Washington Square East, New York City.

Asas, Caixa Postal 1967, Rio de Janeiro, Brazil.

Aviation, 330 West 42nd St., New York City.

Aviation Weekly, 9401 Western Ave., Los Angeles, California.

L'Aviazione, Corso Umberto 504, Rome, Italy.

Boletin de Aeronautica Civil, Calle Azcuenaga 923, Buenos Aires, Argentina.

Boletin Oficial de la Direccion General de Aeronautica, Magdalena 12, Madrid, Spain.

Bulletin du Service Technique de l'Aeronautique, 72 chaussee de Waterloo, Rhode-Saint-Genese, Belgium.

Bulletin Officiel du R.A.A., 6, Rue de Mezieres, Paris (6), France.

Bulletin Technique du Bureau Veritas, 31 rue Henri-Rochfort, Paris (17), France.

Canadian Aviation, Journal Building, Ottawa, Canada.

Deutsche Luftwacht, Schoeneberger Ufer 46, Berlin W35, Germany.

Les Fiches Aeronautiques, 6 rue Galilee, Paris, France.

Flight, Dorset House, Stamford St., London, S.E.1, England.

Flugwesen, Konviktska 22, Prague 1, Czechoslovakia.

Indian Aviation, P. O. Box 2361, Calcutta, India.

Journal of Air Law, Northwestern University, Chicago.

Journal of the Institute of Engineers, Australia, Science House, Gloucester and Essex Sts., Sydney, N. S. W., Australia.

Journal of the Royal Aeronautical Society, 7 Albemarle St., Piccadilly, London, W.1, England.

Journal of Scientific Instruments, 1 Lowther Gardens, Exhibition Rd., London, S.W.7, England.

Journal of the Society of Automotive Engineers, 29 West 39th St., New York City.

Luftfahrt-Forschung, Verlag Oldenbourg, Munich 1, Germany.

Die Luftreise, Lindenstr. 35, Berlin SW68, Germany.

Luftfahrt-Literaturschau, Z.W.B. bei der D.V.L., Berlin-Adlershof, Germany.

Model Airplane News, 551 Fifth Avenue, New York City.

Monthly Weather Review, U. S. Dept. of Agriculture, Washington, D. C.

Motor and Flying, 24 Bond St., Sydney, N. S. W., Australia.

National Aeronautic Magazine, Dupont Circle, Washington, D. C.

Official Aviation Guide, 608 S. Dearborn St., Chicago.

The Pilot, Grand Central Air Terminal, Glendale, California.

Il Politecnico, Via Spiga 32, Milan (2/7), Italy.

Popular Aviation, 608 S. Dearborn St., Chicago.

Proceedings of Institute of Radio Engineers, 330 W. 42d St., New York City.

Review of Scientific Instruments, 175 Fifth Ave., New York City.

Revista de Aeronautica, Ministerio de la Guerra, Apartado 1047, Madrid, Spain.

Revue de l'Armee de l'Air, 55 quai des Grands-Augustins, Paris, France.

Revue du Ministere de l'Air, 71 avenue des Champs-Elysees, Paris, (8), France.

Rivista Aeronautica, Ministero dell'Aeronautica, Rome, Italy.

The Royal Air Force Quarterly, Gale & Polden Ltd., 2 Amen Corner, London, E.C.4, England.

Southern Flight, Ledger Building, Fort Worth, Texas. Texas.

Sportsman Pilot, 515 Madison Ave., New York City.

Technika Vosdushnogo Flota, U1. Radio 16, Moscow 16, U. S. S. R.

La Technique Aeronautique, 2 rue Blanche, Paris (9), France.

U. S. Air Services, Transportation Building, Washington, D. C.

Western Flying, 420 S. San Pedro St., Los Angeles, California.

Wirtschaft Technik Verkehr, Alte Jakobstr. 148/155, Berlin SW68, Germany.

Zeitschrift für angewandte Mathematik und Mechanik, Kulmstr. 1, Dresden A24, Germany.

AERONAUTICAL REVIEWS

These brief reviews of recent articles on aviation subjects are published by the Army Air Corps for the information of its officers, and are printed here each month by permission of the Chief of the Air Corps. The articles listed may not be obtained from the Army Aeronautical Museum Library as these magazines are available to Wright Field personnel only.

Aerodynamics

Eleventh Annual Aircraft Research Conference. M. Watter. Outline of the research being carried on at the N. A. C. A. laboratories at Langley Field with particular reference to the high-speed wind tunnel, effect of surface on resistance, stability and control, cowling and cooling, hydrofoils, highly tapered wings, and engines. Aero Digest, June 1936, pages 48, 50, 84. 1 illus.

An Electric Steelyard Balance. M. Kramer, J. E. W. Ginger and R. Hounsfield. Six-componet balance with remote autographic recording installed in the new D. V. L. wind tunnel. Conditions imposed on the designers of the balance, increased precisions obtained, mechanical accuracy of the movement of the jockey, electrical operation of standard steelyard balances and of the new balance, characteristics of the system adopted, results obtained with the balance, and a method of testing the accuracy of the complete balance are described. Aircraft Engineering, June 1, 1936, pages 151–153. 12 illus.

Winds Over Langley. Research work in progress at the N. A. C. A. Langley Aeronautical Memorial Laboratory, as demonstrated at the recent Eleventh Annual Aircraft Engineering Research Conference. The brief review refers to the 500-m.p.h. wind tunnel, tapered wings for high-speed airplanes, smoke-flow studies of the boundary layer, airship research, propeller and lift effect, and engine research. Aviation, June 1936, pages 22–23. 15 illus. Science News Letter, June 6, 1936, pages 359, 362. 1 illus.

On the Common Space Integrals of Aerodynamics. M. M. Munk. Three methods are given for the computation of the kinetic energy of the fluid surrounding the translating solid with three analogous methods for computing the so-called additional apparent mass or its volume, or coefficient. By way of illustration, the different methods of computing the inertia factor are applied to the special case of a Rankine body of infinitely large elongation. Journal Aeronautical Sciences, May 1936, pages 243–247. 37 equations.

Aircraft Design

Basis for a Program of Transatlantic Airplanes. A. Verdurand. The ocean-going seaplane, a seaplane which can land on a heavy swell but cannot take off except from a calm sea, and the seaplane which cannot take off except with the aid of auxiliary means such as the catapault, and the gasoline and heavy-oil engine as well, are compared in regard to their efficient use in transatlantic service. Payload, radius of operation, tonnage, and speed of each type of plane, and the number of passengers, price per passenger, and per passenger-kilometer on several routes are considered. L'Aeronautique, April 1936, pages 72–77. 3 illus.

Firing from a Cannon of the 18th Century at the Hypothetical Airplane of the N. A. C. A. Engineers. W. Margoulis. Distrust of the speed of sound in the supersonic regions which aerodynamicists study. The author believes that flight at speeds higher than that of sound, say 1200 km. per hour, does not offer any insurmountable difficulties, and illustrates his theory with a photograph of the shock waves on a projectile fired at 680 m. per second. He remarks that for propellers there seems to be no sound barrier and considers the hypothetical airplane of John Stack of the N. A. C. A. designed for attaining a speed of 874 k.m. per hour. The problem of supersonic wind tunnels, the author's design, and the transmission of heat to the walls are discussed. Les Ailes, April 30, 1936, page 5. 3 illus.

High-Altitude Transport. W. C. Rockefeller. Conventional airplanes with the addition of extreme supercharging and pressure cabins are considered for high-altitude operation. An aerodynamic analysis is made from which a basis for comparison with flight at lower altitudes is established and the meteorological influences are taken up. Distances are given over which flights at altitudes below 15,000 ft., of 15,000 to 25,000 ft., above 25,000 ft., and at 40,000 ft. are justified. Journal Aeronautical Sciences, May 1936, pages 234–236. 4 illus.

Aircraft. In a recent check of S. A. E. Standards for aircraft parts and a comparison with Army-Navy Standard specifications, it was indicated that some revisions, largely in the nature of refinement, should be made to bring the present S. A. E. Standards up to date. Brief discussion. S. A. E. Journal, June 1936, pages 30, 32.

Experiments in Nosing Over. Specially designed cradle of the Army Air Corps which enables the pilot deliberately to nose over a mock-up of a single-seater pursuit fuselage for a systematic investigation of what happens in a nose-over air-plane accident. Very brief. Scientific American, June 1936, p. 332. 1 illus.

In Search of Safety. Reference to safe-airplane developments in the United States for reduction of landing speeds and details of the new British B. L. G. attachment. This attachment is hinged like a deck-flying arrester-hook from lugs behind the rear wing-root attachments. With its immense compression leg it is said not only to dampen out the shock of arrival in whatever altitude the machine chooses to alight, but to apply the brakes on the forward wheels itself, to prevent the tail skid from striking the ground heavily and making the machine balloon, and to work just as well in cross-wind landings as in a landing into the wind. Brief. Aeroplane Aeronautical Engineering Supplement, June 3, 1936, pages 717–718. 1 illus.

The Irving Balanced Flap. Method of balancing split flaps to reduce the operating loads. Very brief discussion with diagram. Aeroplane, May 27, 1936, page 670. 2 illus.

Sliding Tail Plane. The slidable vertical tail surfaces designed by Teisseyre and Zadaniewski are said to provide an excellent field of fire from the rear and to improve the aerodynamic qualities of the airplane, without increasing the parasite drag and the structural weight, and without compromising the stability of the airplane but rather adding to it. The vertical tail surfaces are in the normal position for take-off and landing but in flight slide down below the fuselage. Les Ailes, May 14, 1936, page 5. 5 illus.

Tail Wheel or Nose Wheel. F. R. Shanley. Characteristics of the front-wheel type of landing gear, basic principles of ground stability or the automatic prevention of ground looping, advantages of a combination of fixed tail wheel and swiveled front wheel, effect of brakes, conditions for wheel stability, determination of forces which tend to continue the wheel deflection or to stop it, and other features of shimmying are considered. Aviation, June 1936, pages 29–32. 7 illus.

On Twenty-Five Years of "The Aeroplane." C. G. Grey. Review of the 25 years of aviation covered by the magazine, with references to the outstanding airplanes and events, development of the Royal Flying Corps and Royal Air Force, and war and post-war aviation. The illustrations include photographs of early and later record-breaking airplanes with a few drawings of the earlier types. Aeroplane, June 3, 1936, pages 696–716. 45 illus.

What the Operator Wants. Opinions of representative British airline operators on the requirements of aircraft and equipment. Flight, May 21, 1936, pages 553–554.

Work of Liore-et-Olivier in the Autogiro Field. Studies of the firm's research bureau have resulted in a more powerful and faster autogiro of unique design. An arrangement for damping the blades in order to avoid the alternating forces which decrease the resistance of the structure, and a landing gear with a vertical displacement of the wheels are described and illustrated. Les Ailes, May 7, 1936, page 5. 5 illus.

Aeronautical Progress 1930–1936. E. F. Relf. Advances made in the technic of research methods, the nature of the new knowledge of aerodynamic phenomena resulting from them, and the reaction on the practical design of aircraft. Nature of the variations of skin-friction drag with Reynolds number, effects likely to be produced by changes of turbulence in the stream, factors determining the magnitude of the maximum lift of wings, and means for increasing lift are discussed in this issue. To be continued. Complete paper presented before the Institution of Civil Engineers. Aircraft Engineering, June 1936, pages 163–166. 8 illus.

Operator Solutions in Airplane Dynamics. A. Klemin and B. F. Ruffner. The effect of gun recoil considered is that of temporarily adding a weight to the airplane, equal to the average recoil, at a distance of seven feet behind the center of gravity. The operator method is given for deriving the equations of the motion of an airplane, verified by recalculation of gust effects, and applied to the problem in airplane dynamics of the longitudinal motions of an airplane when a gun with powerful recoil is fired. Journal Aeronautical Sciences, May 1936, pages 252–255. 1 illus. 22 equations.

Trends in Longitudinal Stability. O. C. Koppen. The differing opinions of airplane designer and pilot regarding a criterion for longitudinal stability are pointed out and that of the designer is criticized. The variation of the period of longitudinal motion with tail size is illustrated for a typical airplane. The effects are shown for changes of airplane density, time unit, ratio of slope-of-the-pitching-moment curve to tail effectiveness, and ratio of the change of moment coefficient with forward speed to the slope-of-the-pitching-movement curve. An additional set of curves for determining the degree of damping is also given. Journal Aeronautical Sciences, May 1936, pages 232–233. 4 illus.

Measurement of Hinge Moments at the Eiffel Laboratory. J. Monnin. Set-up for measuring the hinge moments, the means employed to eliminate the errors and corrections, and the preparation of the models. Test results obtained in regard to the effect of guard plates on the hinge moments of wings of different aspect ratios, influence of the location of the hinge on the moments, influence on the same hinge of the initial opening of the aileron slot, and influence of the angle of slip of the hinge with respect to the direction of the wind. La Technique Aeronautique, No. 139, 1936, pages 40–63. 26 illus.

Modern Developments in the Design of Aeroplanes. E. F. Relf. Characteristics of the Fairey Fox of 1930 are compared with those of the 1934 DeHavilland Comet and the 1935 German Heinkel He70. The improved aerodynamic design and higher speeds obtainable are emphasized. Frictional resistance to motion in a fluid is discussed and the conclusion reached that at the very high Renolds numbers involved in flight, the drag, whether of wings or fuselage, ought, with a good shape, to be approximate to the value given by the turbulent skin-friction curve. Importance of the compressed-air tunnel, tests of roughened airfoils and of a Fairey rough wing surface in such a tunnel, and the behavior of body-wing combinations are taken up. The second article covers drag reduction in connection with engine-cooling problems, new materials and their efficient application to aircraft structures (with a reference to the Wallis-Vickers construction), reduction of landing speeds by means of flaps, the question of take-off, trimming devices for stability, and the investigation of the nature of turbulence. Long abstract of paper presented before the Institution of Civil Engineers. Engineering, May 8 and 22, 1936, pages 513–514 and 572–573.

Engine cooling and resistance, metal construction, the airship, and future developments only are included in a shorter abstract. Engineer, May 8, 1936, pages 481–483.

Shorter abstract including future progress. Flight, May 14, 1936, pages 504–505. 1 illus.

Simplified Method for Calculating the Reactions on the Stick—Case of Gliding Flight. R. Pesek. The force on the stick is a linear function of the dynamic pressure in the simple formulas developed. The stabilizing moment, the deflection necessary for equilibrium, the hinge moment, the force on the stick, and the coefficients of static stability are considered. L'Aeronautique, L'Aerotechnique Supplement, April 1936, pages 40–46. 8 illus.

Sturdiness of Airplanes in Relation to Increase in Speed. A. Fiore. The use of very high strength coefficients in static tests of the present high-speed airplanes is criticized and the necessity for studying the vibrations of the high-speed airplane rather than increasing the static coefficient is pointed out. Natural vibrations of the wing, forced vibrations produced by the engine, atmospheric disturbances, and vortex wash of wing and propeller are considered in detail. Paper presented before the Third National Congress of Italian Engineers. Rivista Aeronautica, April 1936, pages 55–65. 8 illus.

Stress Analysis and Structures

Graphical Calculation for Continuous Beams. L. Kirste. The graphical method given is based on the separation, even in the case of axial compression, of the "bay moments" and the "support moments," and on addition after they have been amplified by additional moments, corresponding to distributed loads of the magnitude MP/EI. The method is general allowing for variation of moment of inertia and for transverse and longitudinal loads, not only from one bay to another, but from point to point. Journal Aeronautical Sciences, May 1936, pages 229–231. 4 illus.

Stressed-Skin Construction. Capt. C. F. Greene. Basic changes in structural procedure brought about through the development of modern aircraft, with an example of the modern stressed-skin wing having longitudinal stringers. A diagram illustrates the progressive failure of the wing and a redesign is given which avoids such a failure. The necessity for so proportioning and distributing the material as to have as little of it as possible become ineffective prior to the general failure of the entire assembly is explained. The effect of adding cockpit fairing to the fuselage is also illustrated. The influence of aircraft design on other types of structures is also referred to. Mechanical Engineering, May 1936, pages 279–282. 4 illus.

Local Reinforcement of Wing Beams. G. Covington. Analysis showing that the progressive type of rivet failure can be eliminated by tapering the ends of the cover plate in such a manner as to stress the rivets equally, and by providing a sufficient number of rivets in the tapered section to transmit into the cover plate its full load. Aero Digest, June 1936, pages 44–45. 3 illus.

The Stressing of Multi-Spar Wings. H. N. Horne. A method previously given for finding the loads in the spars and covering for a wing with two spars and stiff covering is extended to enable loads in the spars and the skin to be found when the wing has more than two spars and the covering is such that it adds to the torsional stiffness of the wing. The loads on the spars to give equal deflections are first found and then the flexural line is obtained from these loads. Flight, Aircraft Engineer Supplement, May 28, 1936, pages 33–36, 8 illus. 4 tables.

Aircraft Performance

Aircraft Performance in Non-Standard Atmosphere. Lt. Col. J. D. Blythe. A method for determining conditions prevailing at a series of tape-line heights in a non-standard atmosphere and application of the results to aircraft performance estimates. Flight, Aircraft Engineer Supplement, May 28, 1936, pages 32–33.

Aircraft Production

Metal Aircraft Construction. F. W. Herman. Manufacturing phases of metal aircraft construction. Very brief abstract of paper presented before the S.A.E. Automotive Industries, June 13, 1936, pages 846–847.

Flying-Boat Production. Large-scale manufacture of big aircraft at the Saunders-Roe plant. Flight, May 14, 1936, pages 508d–510. 5 illus.

Aircraft

At the Stockholm Show. Review of aircraft, engines, and equipment exhibited at the Swedish Aero Show with illustrations of the Focke-Wulf fighter trainer F.W.-56 and Arado AR. 76 military trainer, as well as of other planes and engines. Flight, May 21, 1936, pages 545–548, 552. 17 illus.

The Stockholm Aero-Show. T. James. Aircraft, engines and equipment displayed by Great Britain, Poland, Finland, Holland, Czechoslovakia, Sweden, and Germany at the Swedish Aircraft Show are reviewed with details of interest of each. Aeroplane, Aeronautical Engineering Supplement, May 20, 1936, pages 638–641. 6 illus.

CANADA

A special six-passenger seaplane, built for the Britain Air Ministry, will be used in preliminary flights in connection with the opening of the transatlantic route. Brief reference only. Aero Digest, June 1936, page 76.

FRANCE

400 KM.-H. The two-engined Breguet 460-I has attained 400 km. per hour in tests with two Gnome-Rhone K14 engines. Photographs only. Les Ailes, May 14, 1936, page 1. 3 illus.

Bombers. The Farman F-221 four-engined and the F-222 bombers, the rear gun cockpit, and the landing gear. Photographs only. Les Ailes, May 21, 1936, page 1. 7 illus.

In the Field of Tests at Villacoublay. The Mureaux 115 R-2 airplanes ordered for the French Army differ from the type 113 R-2 in that they are equipped with the Hispano. 12-Y.C.R.S. "moteur canon." The first Liore-Dewoitine D-501 with a "moteur canon" have been received. Brief references. Les Ailes, May 21, 1936, page 3.

The Morane-Saulnier M.S.-350 Biplane. A. Frachet. The single-seater plane for training in acrobatics and piloting of high-speed planes is equipped with a Renault 6-Pei 220-hp. engine and flies at a top speed of 250 km. per hour. Long description. Les Ailes, May 14, 1936, page 3. 3 illus.

Recent French Military Equipment. The Mureaux 180 C.2 two-seater pursuit, the Mureaux 200 A.3 three-place scout and its range of fire, the Potez 453 single-seater pursuit, the C.A.M.S. 110 armament and control arrangements, and the Dewoitine D.513 single-seater pursuit are briefly described and illustrated. Reference is made to the Romano R.80 and R.90. Revue de l'Armee de l'Air, May 1936, pages 579–588. 18 illus.

Aerial Politics. The Block 130 has a top speed of 380 km. per hour, the Bréguet 460 of 390 km. per hour, and the Potez 54 of 400 km. per hour. Editorial answering an article in "The Aeroplane" which stated that French military planes were incapable of flying at more than 150 m.p.h. Brief. L'Aerophile, April 1936, page 74.

French Airplanes. Characteristics of construction, performance, photograph and 3-view drawing of the following aircraft:—The Mureaux 113 R2 two-place reconnaissance and observation, Mureaux 115 R2 two-place reconnaissance and pursuit, Mureaux 180 C2 two-place pursuit, Bleriot 110 long distance, Bleriot 290 touring amphibian, Bleriot Spad 510 single-seater pursuit, Bleriot 5190 Southern transatlantic postal seaplane, Gourdou-Leseurre 832 Hy seaplane for shipping on distant cruises, Hanriot H 16 preliminary training, Hanriot 161 light training and observation, Hanriot 180 two-place light observation, Hanriot 182 ED 2 preliminary training, Henriot H33 two-place training, Hanriot H36 two-place general service, P. Levasseur P.L. 15 torpedo ship bomber seaplane, P. Levasseur P.L. 101 three-place ship observation seaplane, Romano R.80 two-place acrobatic, and the Romano R.160 colonial planes. La Technique Aéronautique, No. 139, 1936, pages 4–39. 36 illus.

A French Long-Range Boat. The Latécoère 582 long-range naval reconnaissance flying boat described in a three-engined braced high-wing monoplane with a top speed of 170 m.p.h. at 13,000 ft. How the design meets the requirements of the French government for this type of plane, and its marine qualities are briefly discussed with a reference to its armament. Hull, float, main plane and tail constructional features are illustrated. Aircraft Engineering, May 1936, pages 134-135. 6 illus.

A New Commercial Dewoitine. The Dewoitine D-620 21-passenger three-engined low-wing all-metal transport plane described is competing for replacement contracts on the Air France lines. It has a useful load of 8,070 lb. and top speed of 217 m.p.h. at 2,000 meters. It is powered by three Gnome-Rhone 14 Krsd 14-cylinder 880-hp. engines. Aircraft Engineering, May 1936, page 136. 2 illus.

The Potez 60 Two-Place Touring Plane. Characteristics and performance of the two-place light plane and drawings illustrating various parts of the construction. L'Aéronautique, April 1936, pages 77–79. 10 illus.

Structural Elements of the Caudron "Typhon." Drawings only with brief explanation. L'Aeronautique, April 1936, page 91. 7 illus.

Lateocoere Torpedo Seaplane. The two-float low-wing monoplane now being tested may be used as a three-place reconnaissance plane and should attain a 300-km. per hour speed. Brief reference. Les Ailes, May 7, 1936, page 4.

Technical Notes. The Bloch 150 single-seater pursuit has a low wing containing a Messier retractable landing gear and two guns with slots on the lower surface. Brief reference. Les Ailes, May 7, 1936, page 4.

The Morane 405 single-seater pursuit has been tested 80 hours so far. Brief reference to the fact that difficulties have arisen with the circulation of cooling liquid and the adaptation of a good variable-pitch propeller.

The Mureaux C. 710 is the first of the small pursuit ships derived from the technique of the Coupe Deutsch and is fitted with a Renault 12-cylinder inverted 450-hp. engine. Brief reference. Les Ailes, May 14, 1936, page 3.

Two New Transatlantics. The Loire-103 seaplane with four Hispano 12X engines and the LeO-H 47 seaplane with four Hispano 12Y engines are briefly described. Les Ailes, May 7, 1936, page 9. 1 illus.

GERMANY

The Dornier Do-18 Transatlantic Seaplane. A. Frachet. The Dornier seaplane described in detail is designed for the transportation of 150 kg. of mail, is equipped with two tandem Junkers-Diesel Jumo-5 540-hp. engines, and has a range of 4,450 km. cruising at 210 km. per hour. A Junkers auxiliary fin is provided which serves as a high-lift flap, and the construction of the airplane is reinforced for catapulting. Les Ailes, April 30, 1936, page 3. 3 illus.

Focke-Wulf FW 58 "Weiche." Description of the bimotored military plane for instruction in gunnery and blind flight. In addition to a drawing and three photographs of the exterior of the plane, an interior view of the cockpit is given. Rivista Aeronautica, April 1936, pages 67–71. 5 illus.

Heinkel 111 Bimotor. Brief illustrated description of the two-engined passenger transport for Deutsche Lufthansa. L'Aéronautique, April 1936, page 71. 3 illus.

Junkers Ju 86 High-Speed Bimotored Transport. Very brief details and four photographs illustrating the plane with both water- and air-cooled engines. L'Aeronautique, April 1936, page 80. 4 illus.

A Continental Trainer. The Buecker Jungmann biplane briefly described has been developed for school and practice flying, and is said to be remarkable chiefly for its performance on comparatively low power (80 hp.). Flight, May 28, 1936, page 588. 1 illus.

The Four Winds. A very large Dornier four-engined flying boat, the Do. 20, is being built which will cruise at 150 m.p.h. for 3,000 miles. Brief reference. Flight, May 21, 1936, page 531.

GREAT BRITAIN

The Armstrong-Whitworth Whitley. The Whitley twin-engined middle-wing monoplane heavy bomber is protected by enclosed gun turrets at the nose, tail, and amidships, the last position being located on the underside of the fuselage behind the wing. Dimensions with only a few details and photographs. Aeroplane, May 13, 1936, page 611. 3 illus.

The Hornet-Moth Light Aeroplane. Two-place DeHavilland airplane and its 130-hp. Gipsy Major engine are described in detail with illustrations of the plane, engine, tank, landing gear, and a compression leg which constitutes combined spring and oil-cushioned shock absorbers. A supplementary plate of the magazine illustrates many structural details. Engineering, May 8, 1936, page 498.

New British Service Equipment. The Royal Air Force Fairey Battle and the Naval Supermarine Seagull V amphibian for catapult launching. Photographs only with very few details in the caption. Aircraft Engineering, May 1936, page 137. 4 illus.

The New Monospar. A very pronounced sweep-back of the wings, a short nose of the fuselage almost in line with the two propellers, a very low position of the tailplane over the ground, a straight fuselage bottom, and a somewhat hunch-backed shape of the fuselage are features of General Aircraft's S.T. 18 which are not generally found in twin-engined aircraft. Reasons for adopting these features are given by the designer. The design of the retractable landing gear with Dowty telescopic legs is explained with a diagram, and the fuselage structure is illustrated. The plane carries 10 passengers and cruises at nearly 200 m.p.h. Flight, May 7, 1936, pages 478–480. 5 illus.

British Military Aircraft. P. M. Magruder. New types of British Army co-operation, reconnaissance and general-purpose, fleet-spotter-reconnaissance, and coastal-reconnaissance aircraft are briefly described along with older designs now in use. Most important in the present trend of British military aircraft are the long-range bomber and the interceptor fighter, the trend in the design of both fighter and bomber

being away from the biplane and toward the low-wing multi-engine monopalne with flaps. Reference is made to engines and to armament, especially to the "moteur canon." In comparison with the military planes of the United States the latest British interceptors are considered as fast as our pursuit types, but in the bombing category the British are said to lag behind. Continuation. Aero Digest, June 1936. pages 27-29, 82. 12 illus.

The D. H. Albatross. At a gross weight of 25,000 lb. the D. H. Albatross monoplanes ordered by the Air Ministry for experimental transatlantic flying will have a maximum speed of about 250 m.p.h. Brief reference. Flight, May 28, 1936, page 573.

Instrumental. Drawing illustrating the control layout in the cockpit of a DeHavilland 86A transport. Flight, May 31, 1936, page 540a. 1 Illus.

Modern Commercial Aircraft Reviewed. Details of over 30 types of commercial aircraft, mostly British, including those produced by Airspeed, Armstrong, Whitworth, Blackburn, Boulton and Paul, Bristol, B.A. and B.M.A., Cessna, DeHavilland, General Aircraft, Handley Page, Heston, Parnall, Percival, Phillips and Powis, Pobjoy, A. V. Roe, Saro, Short and Stinson. Flight, May 21, 1936, pages 524–530. 30 illus.

A Social Occasion. Demonstrations of the latest civil aircraft at the Royal Aeronautical Society Garden Party with a few details of unusual features and performance attained. Flight, May 14, 1936, pages 500–502. 9 illus.

Transport Airplanes. Airspeed, Blackburn, Bristol, British Aircraft, British Marine Aircraft, Cierva, DeHavilland, General, Heston, Mayo Composite Aircraft, Parnall, Percival, Phillips and Powis, Pobjoy, A. V. Roe, Saunders Roe, Short, Brian Allen, and Mollison transport planes are briefly reviewed. Aeroplane, May 6, 1936, pages 557–564. 32 illus.

HOLLAND

The Koolhoven F.K. 50-B two-engined bomber, derived from a transport plane, has a speed of 400 km. per hour at an altitude of 4,750 m., and carries a military load of 1,400 kg. for 1,150 km. Photograph only. Les Ailes, April 30, 1936, page 9. 1 illus.

ITALY

The Fiat C.R.-33 Single-Seater Pursuit. The metal biplane described is equipped with a Fiat A-33 R.C. 700-hp. engine and is derived from the C.R.-30 and C.R.-32 models. At an altitude of 3,500 m. its range is two hours at 350-km.-per-hour cruising speed and its top speed 420 km. per hour. Les Ailes, May 7, 1936, page 3. 3 illus.

JAPAN

Japan. New Japanese army training planes of the Series 95, types I, II, III, will replace the existing training planes of the B-1 and E-1 types. Brief reference only with a few details. Aero Digest, June 1936, page 78.

U. S. A.

An American Naval Pursuit Ship. The Grumman F2F-1 attained a speed of 386 km. per hour during its tests. Brief reference. Les Ailes, May 14, 1936, page 5.

The Four Winds. The flat of the latest Northrop attack plane is perforated with large holes to reduce buffeting. Brief reference. Flight, May 28, 1936, page 573.

An Airplane Which Realizes Flapping Flight. An unusual American design developed by Lewis is discussed. A previous description appeared in "Popular Aviation." Two very large propellers operate at the trailing edge of the wing in addition to the smaller propeller at the nose of the fuselage. Les Ailes, April 30, 1936, page 4. 2 illus.

The Four Winds. A Seversky two-seater fighter with a 750-hp. Wright Cyclone engine is said to make 280 m.p.h. at 11,000 feet. Brief reference. Flight, May 7, 1936, page 483.

Hughes. After improvements, the Hughes' racer will be submitted to Army enginers at Dayton for static tests. Brief reference. Western Flying, May 1936, page 32.

Seversky Airplanes. Structural and design details of the Army BT-8, as well as specifications for the two-place amphibian fighter and for an experimental two-lpace pursuit or observation plane. Crushproof headrest, liquid-tight wing structure containing the gasoline tank (with a reference to a special type of patch designed to repair bullet holes), discelerators, and landing gear of the BT-8 are brieft described. Maximum and landing speeds are included in the specifications given for the other two planes. Aviation, June 1936, pages 34–36. 8 illus.

United States. Vultee VII military plane has a top speed of 347 k.m. per hour at an altitude of 4,000 meters. Photograph only showing load of bombs under the wing. Les Ailes, May 14, 1936, page 8. 1 illus.

Wright-powered Fairchild "45." The new five-place monoplane is powered with a Wright 320-hp. engine and has a top speed of 180 m.p.h. and a landing sped of 49 m.p.h. with flaps. Detailed description. Aero Digest, June 1936, pages 56, 59. 4 illus.

Minor modifications to increase the performance and specifications. Brief. Aviation, June 1936, page 39. 2 illus.

U. S. S. R.

Russian Light Airplane AT-1. The AT-1 low-wing 3-seater monoplane described was designed to meet the requirements of the safe-airplane competition in Russia. The airplane is stressed to take either a 110- or 150-hp. engine and has a top speed of 118 m.p.h. and a landing sped of 37.5 m.p.h. without flaps. Aero Digest, June 1936, page 54. 2 illus.

Airships

Air and Water. It is reported that two airships similar to the "Hindenburg" are to be ordered by Japan for purpose of establishing a five-day commercial air service between Tokio and San Francisco. Brief reference.

Construction has begun on a new semi-rigid airship in U. S. S. R. which is designed for research flights in the Arctic. Brief details. Engineer, May 29, 1936, page 571.

The "Hindenburg" Specifications, reason for reduction of fineness ratio, manual control, fire precautions, power plant, landing wheels, structure, central electric station, control car, and passenger accommodations are reviewed in a general description. Scientific American, June 1936, pages 330–331. 6 illus.

Transoceanic Airships. K. Arnstein. Potential traffic for a transatlantic air service, requirements for an ocean service for any commercial transportation vehicle and for air transportation in particular, inherent safety factors of the airship, its speed, economic performance, and passenger comfort. Aviation, June 1936, pages 11–14. 4 illus.

The Zeppelin Airship LZ 129. W. E. Dörr. Hull construction, gangways, fins, outer cover, gas bags, electric plant, control car, controls, ballast, instruments, radio, engineers' room, and passengers' quarters are described. An article on the power plant by F. Sturm follows. Drawings and photographs illustrate construction details and the layout of the airship. Aircraft Engineering, June, 1936, pages 155–162. 28 illus.

Propellers

Tests of Propellers with Regulated Variable Pitch in the Large Wind Tunnel at Issy. Apparatus designed for testing two three-bladed propellers turning in opposite directions, and the method of measuring the cyclic variation of the incidence of the blades are briefly described. Les Ailes, May 14, 1936, page 4. 1 illus.

Analysing Propeller Vibrations. L. A. Clousing. Air Corps studies of propeller vibration, initiated by Captain H. H. Couch, an N.A.C.A. method, a more accurate method developed by R. F. Conner of the Material Division, and the procedure followed by the Material Division when purchasing newly designed propellers for the Army planes are described. The problem of vibration failure with the manually-operated controllable-pitch propeller, its elimination with the constant-speed propeller, and the smoother power output obtained with the new 14-cylinder radials are referred to. Western Flying, May 1936, pages 11, 12, 26, 28, 45. 6 illus.

Characteristics of Braked, Locked, and Free-Wheeling Two- and Three-Bladed Propellers. F. J. Malina and W. W. Jenney. The three-bladed propeller and its effect on airplane characteristics are discussed, the two-bladed propeller being used principall for comparison purposes with other available data. A method is developed for calculating the braking force supplied by a dead engine and the formula given is thought to approximate actual conditions closely in view of the considerable amount of friction horsepower data upon which it is based. Negative thrust coefficients for various propeller conditions are shown in a table. Research results obtained at the California Institute of Technology. Journal Aeronautical Sciences, May 1936, pages 237–242. 12 illus. 1 table.

Rocket Propulsion

Exciting While It Lasts. A rocket-driven tailless airplane was towed to a height of 60 ft. and then flew 1¼ miles after the rockets had been lit. Reference to experiments of Espenlaub and Sander given in a short caption of a photograph of this airplane. Aeorplane, Aeronautical Engineering Supplement, June 3, 1936, page 717. 1 illus.

Engine Design and Research

Air-Cooled Radial Aircraft-Engine Performance Possibilities. R. W. Young. Results obtained in 100-octane (Army method) fuel tests undertaken by the Air Corps and the Wright Aeronautical Corporation, which clearly indicate the marked improvement not only in increased take-off power but also in the extremely low fuel consumption at cruising output made possible by the use of fuels of ultra-high octane rating. Changes in aircraft-engine design which have had a marked influence on increasing the overall performance, fuel economy as the major objective in both military and commercial operation, the need for an instrument to indicate definitely the immediate effect of manipulating mixture control and automatically to regulate the fuel-air mixture ratio are discussed with a description of devices which would fulfill this need. Discussion by F. C. Mock included. S.A.E. Journal Transactions, June 1936, pages 234–256. 31 illus.

Airplane of 1940 Envisioned by British Air Expert. Liquid-cooled engines of high horsepower having many small cylinders are predicted for the future. Brief abstract of paper presented by H. Wood of Rolls-Royce, Ltd. before the S.A.E. Science News Letter, June 6, 1936, page 369.

Carburation Practice in Aero-Engines. F. C. Stokes. Carburetor development from 1919 to 1929 including: the spiral induction system introduced in the Cosmos Jupiter engine; rotating fan used in the Armstrong-Siddeley Jajuar; a third method of distribution for radial engines in use on the Wright Whirlwind; the Bristol triplex carburetor incorporating the diffuser in the carburetor body and conveying the emulsion to the choke by duct (described in great detail); the duplex carburetors of the Rolls-Royce normally aspirated engine; two Stromberg throttle-enrichment schemes; problems in carburetor design brought about by the introduction of the supercharged engine; and the Rolls Royce Kestrel induction and carburetion system with supercharger. Continuation. Aircraft Engineering, June 1936, pages 167–171. 16 illus.

The Enemies of the High-Speed Diesel Engine Are the Very Elevated Maximum Pressures. P. Dumanois. Question of whether it is possible to use the true Diesel cycle with the limitations of maximum pressure. Effects of delay of ignition and the quality of the fuel are pointed out and the improvement in smoothness of combustion with supercharging is discussed. Designing a high-speed engine with direct injection for the Diesel cycle without fear of excessive pressures with constant gasification at practically constant advance, is said to be possible if fuels are used which have a low retarded ignition (as in the case of gas oil from the Irak), or if an injector is designed to operate at constant pressure but with a variable opening section. Paper presented before the Societe des Ingenieurs de l'Automobile. Les Ailes, May 7, 1936, page 4.

Carburation Practice in Aero-Engines. F. C. Stokes. 1914-1918 carburetor designs for military aircraft engines. Major requirements of carburetors for military purposes are itemized and the Claudel Hobson air bleed diffuser carburetor, various types of manual mixture or altitude control, the Zenith 55 DC carburetor, the B.M.W. and Mercedes carburetors developed for use with German high-compression aero engines, the Maybach carburetor for Zeppelin engines, the Liberty and Napier engine induction systems, and a standard method of flow comparison are described. Continuation. Aircraft Engineering, May 1936, pages 129-133. 12 illus.

Engine Types and Fuel Requirements. F. C. Mock. Avoiding the small power loss caused by heating of the charge. The three means suggested include injection into the properly designed supercharger of a radial engine, timed injection into the intake pipes of nearly any form of engine, and injection into the cylinders. Different requirements for injecting certain fuels boiling between 200 and 450° F., between 300 and 560° F., and above 560° F. are outlined. A recommended design for injection into the supercharger, types of intake valves which deliver air unsymmetrically into the cylinder spaces, and a combustion-chamber form for reducing detonation are illustrated. Any successful design of compression-ignition aircraft engine in the future will be a two-cycle stream-line uniflow, positively-scavenged and supercharged engine with

short fuel lines according to the author's predictions. Long abstract of paper presented before the S.A.E. Automotive Industries, May 30, 1936, pages 774–775, 780. 3 illus.

Results of Inadequate Cooling. M. O. Teetor. Harmful effects of inadequate cooling of portions of the cylinder bore. Thermal distortion taking place in the cylinder blocks and the associated evils, breakdown in lubrication when the surface temperature exceeds 400° F., the material factor, and the difference in cylinder-surface temperature of three different cylinders tested are discussed. Abstract of paper presented before the S.A.E. Automotive Industries, May 30, 1936, pages 770–771. 2 illus.

Engines

Diesel Engines of the "Hindenburg" LZ-129 Zeppelin Airship. Development work undertaken by Daimler Benz on Diesel engines for the Hindenburg with a few details of the Mercedes-Benz LOF 6 900- to 1200-hp. Diesel engines finally adopted. Automobiltechnische Zeitschrift, April 25, 1936, pages 207–208. 2 illus.

Diesel Engines in Russia. Characteristics of automotive Diesels in use in Russia. Short table and very brief discussion. Automobiltechnische Zeitschrift, April 25, 1936, page 215.

Engines for Commercial Aircraft. Details of British aircraft engines including Armstrong-Siddeley, Bristol, British Salmson, Cirrus-Hermes, DeHavilland, Napier, Pobjoy, Rolls Royce, Villiers-Hay, and Wolseley products. Flight, May 21, 1936, pages 557-560. 13 illus.

Interesting Results with the Daimler-Benz 1200-Hp. Engine. R. Rabion. The Daimler Benz LOF-6 Diesel engines powering the Hindenburg. Design and comparison with Deschamps, M.A.N. and Losange heavy-oil engines. Les Ailes, May 21, 1936, page 5. 5 illus.

The Power Plant. Development of the LOF-6 Daimler-Benz compression-ignition engines for the LZ-129 airship as well as calculation of and tests for torsional vibration of the power plant as a whole. Performance curves of a two-stage compressor, a rotational oscillations diagram, lubrication diagram, relative resonance amplitudes of the engine-car installation, rotational oscillation amplitudes, and full-throtte, propeller-power and specific fuel-consumption curves. Aircraft Engineering, June 1936, pages 161-162. 7 illus.

Technical Notes. The 9-cylinder Lorraine "Algol" has been equipped with direct fuel injection. A Lorraine single cylinder is being tested which is designed as part of an 18-cylinder 1100-hp. engine. It is said that Junkers has constructed an 8-cylinder 1200-hp. engine of the Jumo heavy-oil type. Brief references. Les Ailes, May 14, 1936, page 3.

Aero-Motors. D H Gipsy Six and Gipsy Major, British Salmson A.D. 9R, Villiers Maya, Pobjoy Niagara III, Cirrus Minor, Napier Rapier V, Armstrong-Siddeley Cheetah Mark IX and Tiger IX, Bristol Mercury IX and Pegasus X, and Wolseley Scorpio engines. Photographs with details in brief captions. Aeroplane, May 6, 1936, pages 566–568. 15 illus.

British High-Speed Oil Engines. Designs for road transport, rail, and marine purposes are described in detail. This article is followed by two describing Continental and American oil engines. Automobile Engineer, May 1936, pages 162–169. 21 illus.

The Four Winds. An 18-cylinder two-row radial is the latest Gnome-Rhone product. Brief reference. Flight, May 14, 1936, page 503.

Aircraft Oil Engines. Bristol, Phoenix, Rolls-Royce converted Condor, Napier Culverin, Junkers, Clerget-Hispano, Salmson, and Deschamps oil engines for airplanes, and the Beardmore and Mercedes-Benz airship engines are described and illustrated. Automobile Engineer, May 1936, pages 212-215. 9 illus.

Schliha Two-Cylinder Two-Cycle Engine. Design and specifications of a small 36-hp. German engine. Rivista Aeronautica, April 1936, pages 79–80. 2 illus.

Specifications of High-Speed Oil Engines. Tables of specifications for American, British, German, French, and miscellaneous Continental high-speed of engines. Automobile Engineer, May, 1936, pages 186–211.

Accessories

Fuel Injection Equipment. The equipment described for metering, synchronizing, and discharging heavy oil includes C.A.V.-Bosch, Simms "Uniflow," Scintilla, Ganz-Jendrassik, Ex-Cell-O, Hesselman, Bryce, E-H, Beardmore, Deutz, Blackstone, and Cummins appliances. Automobile Engineer, May 1936, pages 181–185. 18 illus.

Zenith Carburetor Company of France. Reported order from the French Air Service for Stromberg carburetors, a new type with unusual chaacteristics being subjected to tests by a number of squadrons. Brief reference with an editorial comment that this may be the automatic-mixture-control carburetor described in the May 2 issue. Automotive Industries, May 23, 1936, page 40.

Engine Testing

A Cathode-Ray Indicator. E. M. Dodds. Cathode-ray engine indicator with a carbon-disk type of pressure element, and its application in engine research for determing ignition lag in Diesel engines, the origin of sound in detonation, and causes of Diesel-engine knock. The reason why fuels of high compression-ignition temperature knock more in a Diesel engine is also discussed. Abstract of paper presented before the S.A.E. Automotive Industries, May 30, 1936, pages 768–770. 3 illus.

High-Speed Motion Pictures of Engine Flames. G. M. Rassweiler and L. Withrow. To record the phenomena occurring within the combustion space of an operating gasoline engine, a special motion-picture camera described was constructed at General Motors which utilizes continuous film and image motion synchronized by means of thirty lenses caried in a disk mounted on the engine crankshaft. Pictures which present an unobstructed view of the entire combustion chamber were obtained by solving the problem of mounting a large quartz plate in the cylinder head. Thirty pictures of a single explosion are photographed at rates up to 5,000 pictures per second and at the same time a pressure-time curve of the explosion is recorded. Paper presented at a Symposium of Motor Fuels. Industrial & Engineering Chemistry, Industrial Ed., June 1936, pages 672–677. 6 illus.

Abstract. Automotive Industries. June 13, 1936, pages 844–846. 2 illus.

Engine Manufacture

Nitralloy Cylinder Barrels for Airplane Engines. E. F. Cone. Metallurgical problems solved by Wright Aeronautical Corporation in selecting a material for cylinder barrels for its new 800-hp. heavy-duty airplane engines. Composition of the nitralloy, how forgings were made and their heat treatment, and the nitriding operation are covered. Metals and Alloys, May 1936, pages 119–121. 5 illus.

The Manufacture of Alloy Stampings. Production of stampings for crankcases, pistons, connecting rods, and propeller blades. Aircraft Engineering, June 1936, page 175. 2 illus.

Fuels and Lubricants

100 Octane Fuel. Lieut. F. D. Klein. Full-scale engine tests conducted by the Air Corps in 1934 showed that an increase of 15–30 per cent in power output is possible with Army 100-octane fuel over that obtainable with Army 92-octane fuel. Very brief abstract of paper presented before the S.A.E. discussing future possibilities of 100-octane engine fuel. Automotive Industries, June 13, 1936, page 847.

Natural Trends. T. W. Legatski. Volatility trends of motor fuel and the relatively small part played by natural gasoline in this changing picture. Paper presented before the N.G.A.A. Oil and Gas Journal, May 21, 1936, page 120.

Potential Advantages of Volatile Fuel Discussed before N.G.A.A. Meeting. D. H. Stormont. Trends in motor-fuel volatility, their immediate effects on automotive design and performance, and the potential advantages that could be gained through the use of more volatile fuels in suitably designed engines. Abstracts of papers by G. G. Brown, W. C. Lovell, and G. Way. Oil and Gas Journal, May 21, 1936, page 30.

Regular Aviation Gasoline Gives Way to 100 Octane Motor Fuel Blends. Field tests on iso-propyl ether blends, a new high-octane blending agent, are discussed by Major E. E. Aldrin and H. E. Buc. Test results obtained by the Air Corps with Army 100-octane fuel are reviewed by Lieutenant F. D. Klein with a reference also to the Bureau of Aeronautics specifications covering high-octane aviation gasoline. A. M. Rothrock briefly describes the N.A.C.A. test apparatus which was used to observe the effects of a displacer piston on air flow in a compression-ignition engine and the effects of air flow on the fuel spray and flame formation. Abstracts of papers presented before the S.A.E. Oil and Gas Journal, June 11, 1936, pages 25–26. 1 illus.

Gasoline and Alcohol-Gasoline Blends. L. T. Brown and L. M. Christensen. Influence of air-fuel ratio, engine speed, and throttle opening upon relative power output, specific fuel consumption, and carbon monoxide production. Equipment, methods and results obtained in research at Iowa State College. Industrial and Enginering Chemistry, Industrial Ed., June 1936, pages 650–652. 1 illus.

A Masterpiece in Oils. D. R. Pye. Structure and behavior of molecules in a lubricant and a new theory of friction. Brief abstract of paper entitled "Slippery Surfaces," the 24th Wilbur Wright Memorial Lecture of the Royal Aeronautical Society. Aeroplane, May 27, 1936, pages 667–668.

Short abstract. Flight, May 28, 1936, page 579.

Instruments

Aircraft Sextant. New aircraft bubble sextant with which the altitude of heavenly bodies may be measured without depending on a sea horizon. The sextant was designed by Bausch & Lomb laboratories from plans submitted by the Bureau of Aeronautics and Lieutenant Commander P. V. H. Weems. Short description. Aero Digest, June 1936, page 60. 1 illus.

Dalton Air Navigation Computer Type E-1A. Lieut. Commander P. V. H. Weems. An air navigation computer, one of the latest of a series of dead-reckoning computers especially designed for the U. S. Army Air Corps, is described in detail with several examples of operation. Aero Digest, June, 1936, pages 52–53. 3 illus.

Pressure Indicator with Electrical Recording. A. Hasse. The pressure measuring device described is suggested as an altimeter for aircraft. It operates on the Bourdon system but with electrical recording and was developed for recording rapid pressure variations. The several measurement ranges combined in this device may be set by hand or automatically as soon as certain limits are exceeded. V. D. I., May 9, 1936, pages 563–564. 2 illus.

Altitude Measurement in Flight. Lieut. L. Aussenac. Necessity for accurate instruments to indicate the absolute or relative altitude in bombing is referred to and the errors in the aneroid altimeter are pointed out. The design of the statoscope, climb indicator, and the American Kollsman altimeter is described. L'Aerophile, April 1936, pages 87–89. 3 illus.

Gallus-Ducommun Aero Calculator. Navigation instrument for calculating angles drift, absolute and relative velocity of the airplane, and wind velocity, consists of a disk for solving $s = vt$, three tables, protractor and pencil. Rivista Aeronautica, April 1936, pages 91–93. 2 illus.

Navigation Instruments. The various types of compasses briefly described include the Aera Ch and DV 10; Salmoiraghi "Atlantico" ns 1206; Short and Mason "Sestrel" MkP and MkIII; and the Barbier, Benard and Turenne A4, "Mengden" CR12, and Morel BS. The Impar L and Ste Gallus 6480 speed-drift indicators, and the "Sestrel" drift indicator are also described. To be continued. L'Aerophile, April 1936, pages 89–91. 10 illus.

New Type of Sextant is Suitable for Use in Air. Aircraft bubble sextant developed by Lieut. Commander Weems and the Bureau of Aeronautics. Brief non-technical description. Science News Letter, May 30, 1936, pages 352–353. 1 illus.

Note on Speed Indicators for Airplanes. Capt. F. Rege-Gianas. Different types of instruments used to measure the velocity of a fluid, and the causes of errors for the specific case of air and the venturi tube. The design of the Siemens hydraulic-mechanical-magnetic transmitter, a magnetic system of remote transmission with alternating current, a variable resistance for remote transmission with continuous current, the windmills of Woltmann and Robinson, and a differential manometer are described and the theory of the venturi and pitot tubes, and the hot-wire anemometer are explained with particular reference to the inevitable imprecision in the indications furnished by these instruments. Rivista Aeornautica, April 1936, pages 15-22. 11 illus.

One Instrument for the Control of Aircraft Engines. Pilot P. Magini. Arrangement for regrouping the engine instruments together in one panel with five compact indicators, each showing only the number to be read. The tachometer is located in the center, the oil- and water-temperature indicators above, and the oil and fuel manometers below. Rivista Aeronautica, April 1936, pages 23–27. 5 illus.

Aerial Photography

Airplanes, Cameras and the Amateur. D. McCash. Lens, shutter, film, filters, type of plane, and protection for the camera. Non-technical discussion for the amateur photographer. Western Flying, May 1936, pages 8–10. 4 illus.

I. Ae. S. Meeting at Rochester, June 16–18. Research work done by the Army Air Corps at Wright Field in the use of aerial photographs for producing certain maps by an aeroprojector will be discussed by Capt. L. J. Rumaggi. Brief reference and outline of the program for the aerial photogrammetry meeting with the American Association for the Advancement of Science. Journal Aeronautical Sciences, May 1936, page 257.

Radio

Air Line Develops Robot Landing. Directional radio beams take over the plane's controls near the airport in United Air Lines' experiments. When the plane intercepts the landing and runway beams at an elevation of approximately 1,000 ft. and at a distance of 5 miles from the airport, the pilot maneuvers the plane so that the horizontal and vertical pointers indicate the plane is exactly on a dead center with the landing and runway beams and, throttling the plane down to 80 m.p.h., he turns the control over to the automatic pilot. Half-page description with illustration of the special antenna located at the nose of the plane. Automotive Industries, May 16, 1936, page 686. 1 illus.

Beacon Marker Transmitter. L. H. Nafzger. At the broadcast station WBNS a radio marker was designed and installed to provide the pilot with signals for use in bad weather. Transmitter and frequency monitor are described. Electronics, May 1936, page 29. 1 illus.

Coastguard Radio. Radio equipment and its operation on board U. S. Coastguard patrol planes. General non-technical description. Wireless World, May 22, 1936, pages 505–506. 5 illus.

Radio Receivers for Pursuit Ships. P. H. Alexandre. Of the three ultra-short-wave radio receivers described for pursuit ship, the first two are regenerative and super-regenerative receivers and the third is a superheterodyne receiver. The author recommends the super-regenerative type for this purpose. Diagrams illustrate the systems. L'Aerophile, April 1936, page 92. 2 illus.

Air Traffic Control. British radio traffic-control and guiding system for airplanes outlined in a general discussion with illustrations of the Marconi equipment for the Empire flying boats and the medium-wave airport outfit of Radio Transmission Equipment, Ltd. Flight, May 21, 1936, pages 540b–540d. 6 illus.

Broadcast Beacons. J. P. Gaty. Faults to be found in the radio compass for air navigation and the solution of eight typical navigational problems involving its use. Diagrams illustrate the determination of track and drift by the radio compass and gyro, locating an airport by means of one off-course radio station under conditions of bad visibility, maintaining track with the radio compass and gyro, direct determination of drift by the radio compass and gyro, descending through total overcast in a spiral around a radio station, explanation of radio-compass action in a spiral arounl a ralio station, and blind approach to an airport with low ceiling and visibility (not zero). A table shows the location of 54 of the major broadcasting stations with respect to the nearest airport. Concuded Aviation, June 1936, pages 15–18. 8 illus.

Horizontal and Vertical Guiding of Airplanes by Radio without Visibility. G. Jacquet. French patent for a radio system for guiding an airplane, horizontally to an airport and then directing its descent vertically along a predetermined trajectory. The vertical guiding is based on a distribution of curves of equal intensity in a vertical plane of fiells radiated by each transmitter. Long description. Revue de l'Armee de l'Air, May 1936, pages 589–594. 7 illus.

Institute Meetings. "Radio in Military Aviation," Colonel L. B. Bender, and "Electric Power Equipment in Military Aviation," Lieut. C. L. Munore. Very brief outlines of papers presented before the Cincinnati Section as well as of those presented before other sections of the Society. Proceedings Institute Radio Engineers, June 1936, pages 817–834.

Instrument Landing System. Application of the automatic pilot to the radio beam landing system which is being tested by United Air Lines. Brief description. Aero Digest, June 1936, page 60. 1 illus.

Leading the Blind. Lorenz system of blind approach to airports. Reference to a paper by H. R. Roderwald of C. Lorenz, A. G., and some of the discussion following its presentation. (Very brief and with no new information regarding the system.) Aeroplane, Aeronautical Engineering Supplement, May 20, 1936, page 641.

Training the Aircraft Operator. W. E. Crook. Methods of training the radio personnel for positions on civil aircraft. General discussion. Wireless World, May 29, 1936, pages 532–534. 5 illus.

Training Pilots to Fly the Beam. A. F. Bonnalie. Method of training pilots to fly blind by the aid of instruments alone, the use of radio in flight training, and some of the developments to be faced by the flight student when he becomes an airline pilot. Reference is made to the instruments calibrated and to a system of timed turns which make instruction in radio flying a relatively exact science. Scientific American, June 1936, pages 322–324. 5 illus.

Meteorology

Haze and Fogs. H. Clusy. Physical study of haze and fogs, visibility through them, their dissipation, and air navigation in spite of them. La Technique Aeronautique, No. 139, 1936, pages 64–73. 2 illus.

Weather Hazards. W. H. Wenstrom. Weather hazards for the airplane, including thunderstorms, chances of lightning actually striking an airplane in flight, turbulence in a large thunderstorm, tornadoes, and waterspouts, as well as the frontal, advection, and radiation types of fog. Three types of icing and conditions under which they may occur are described. Modern forecasting technique and physical weather forecasting technique and physical weather forecasting are also discussed. Continuation. Aero Digest, June 1936, pages 20–23. 10 illus.

Airport Equipment

For Facilitating Fueling. The Blackburn-Electricar refueling unit briefly described consists of a 220-gallon fuel tank and 10-gallon oil tank mounted on an electrically-driven chassis. Flight, May 14, 1936, page 519. 2 illus.

Miscellaneous Equipment

Air Ministry Notices to Ground Engineers. Approved windmill designs for electrical generators for civil aircraft are given in a short table with brief instructions for ensuring the correct functioning of Marconi-Newton constant-speed windmills. Aircraft Engineering, May 1936, page 139.

Auxiliaries and Ancillaries. British raw material, component parts, and accessories which are especially applicable to air transport are listed. Aeroplane, May 6, 1936, pages 575–585. 17 illus.

A New Magneto of the Societe R. B. Details of a new Type P aircraft magneto which has a magnet in steel or nickel-aluminum with high magnetic qualities. Les Ailes, May 21, 1936. page 4.

Toward the Stratosphere. J. E. Sullivan. Provisions for the use of oxygen in the proposed high-altitude operation of transport planes. The The necessity for supplying carbon dioxide as well as oxygen, two types of oxygen apparatus incommon use, seven methods of supplying oxygen to the body which are believed readily adaptable to commercial flying, and the question of "bends" are briefly discussed. Aviation, June 1936, pages 27–28. 1 illus.

Tests of Aircraft Skis. A ski of improved aerodynamic design was developed to meet the requirements of high-speed service and commercial aircraft. Brief outline of development undertaken by the National Research Bureau at Ottawa. Engineer, May 15, 1936, page 516.

The Experimental Development of Anchors for Seaplanes. Wing Commander D. F. Lucking The stocked or fisherman's anchor, the stockless anchor, and the mushrom anchor for seaplanes were tested at Felixstowe for reliability, efficiency, ease of handling, and exemption from tripping. Test results obtained with these and new anchors, and the designs now in use on R.A.F. seaplanes are discussed. Relative importance of anchor and cable is referred to. Long abstract of paper presented before the Institution of Naval Architects. Engineering, June 5, 1936, pages 625–627. 2 illus.

Hydraulic Pumps. Eclipse engine and motor-driven hydraulic pumps for aircraft. Few details. Aviation, June 1936, page 47. 2 illus.

Air Forces

GERMANY

German Aerial Potential in 1936. The German fleet of the first line is composed of around 850 airplanes of different types, while that of the second line and an auxiliary fleet consist of around 450 airplanes. Brief discussion of the airplanes themselves. L'Aerophile, April 1936, page 76.

GREAT BRITAIN

The Air Armament School. Royal Air Force training in gunnery and bombing at Eastchurch. The Lewis-type gun is often mounted on a Scarff ring to simulate aerial firing conditions, and the Vickers is fitted to a rocking fuselage to train pilots in its use. Short rather general description. Flight, May 14, 1936, pages 508b–508c. 7 illus.

The Future of the Fleet Air Arm. The Fleet Air Arm is said to have no flying boats or bombers which bear any comparison with those of other leading foreign powers, and the flying boats recently sent to Alexandria are described as laughable compared to those of Italy. Reference is made to the number of American and Japanese Naval aircraft. Brief account of the attack made by Winston Churchill on the administration of the Fleet Air Arm which was given in a debate on the Supplementary Naval Estimates and refers to the bitter dissatisfaction felt throughout the British Navy at the condition of the Air Arm and the relations under which it is governed. Aeroplane, May 13, 1936, page 594.

Empire Air Day. Events at Henlow, Hendon, Lympne, and Hatfield. A general account of a visit to the Martlesham performance and armament testing sections and to Mildenhall is included. Flight, May 28, 1936, pages 566–572. 10 illus.

New Flying Training Scheme. Regulations for a new system of training to be introduced at the Royal Air Force flying training schools. Flight, May 14, 1936, pages 517–518. Aeroplane, May 20, 1936, page 634.

JAPAN

Aerial Forces—Japanese Military Airplanes in Service. Kawasaki 88 plane for reconnaissance and bombing, Mitsubiski 92 two-seater reconnaissance, and the Kawasaki 92 pursuit. Brief reference to speeds in captions of the three photographs. L'Aerophile, April 1936, page 80. 3 illus.

SPAIN

Special Spanish Furies. An improved type of Hawker Fury for the Spanish Air Force is powered with an Hispano Suiza 12Xbrs engine and has a top speed of 236 m.p.h. The Hawker Osprey for the Spanish Government is also briefly referred to. Flight, May 28, 1936, pages 583 and 565. 1 illus.

U. S. A.

Some Results of American Tests. The test results obtained by the U. S. Army (and very briefly listed) include: the need for increasing the initial speed of machine-gun fire, although little has been accomplished in this direction; machine-gun attack on objects on the ground; furnishing bombs with parachutes to avoid the richochets; illuminating bombs for night bombing; disastrous effects produced on the engine in a dive; conditions of take-off imposed on new airplanes; percentage of pilots selected from training schools; and three categories of military airplanes. Abstract of paper by Lieut. Colonel Jones. Revue de l'Armee de l'Air, May 1936, page 578.

Trainers. The first six of its new BT-8 planes manufactured by Seversky have been accepted by the Air Corps after performance tests. The few details of the plane given include its maximum speed of 176 m.p.h. which is said to make it the fastest training plane in the Air Corps. Aeor Digest, June 1936, page 68. 1 illus.

Why Am I Not Fit to Fly? Lieut. Commander J. R. Poppen. The most frequent causes for rejection for aviation training. U. S. Naval Institute Proceedings, June 1936, pages 811-816.

Air Warfare

The Autogiro as an Aid in Warfare. N. I. Kamoff. Possible military uses of the autogiro from the point of view of vulnerability and utilization in air combat, both in naval aviation and at the front. Abstract from Corriere della Flotta Aerea, Nos. 12 and 13, 1935. Rivista Aeronautica, April 1936, pages 50–52.

Aviation with Heavy Bombers. Colonel Pastier. Use of heavy bombers as military, economic, political, and moral aids, in territorial aerial defense, and in cooperation with land and naval forces. Abstract from Revue du Ministère de l'Air, No. 13, 1936. Rivista Aeronautica, April 1936, pages 41-42.

Confirmation of Air Power. General G. M. Beltrami. Events in international politics from February, 1935, to the present are traced with a discussion of how air power may now be confirmed in the estimates of governments and in the reality of action, factors which determine the power of nations. Rivista Aeronautica, April 1936, pages 1–6.

Defensive Air Combat with Light Bombers. A. Algasin, F. Kovaleff A. Beliakoff, B. Kartacieff and M. Batacieff. The typical examples given for the attack of pursuit planes against bombers include: attack of a patrol of pursuits from one direction; attack from a single direction, from above, from one side, and from below; arranged attack of pursuits against the commander of a patrol of light bombers, from above and from an altitude, as well as from the rear and from below; simultaneous attack against a patrol of light bombers from an altitude and from the rear (two directions) with successive occupation of a posterior dead cone of fire from the patrol; and combat of a patrol of light bombers against a patrol of five pursuits. The attack is developed in steps, from above and from an altitude as well as from the rear and from below according to three different directions. Summary of the volume "The Tactics of Aviation in Bombardment" by five Russians. Rivista Aeronautica, April 1936, pages 43–47. 4 illus.